1. Introduction

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Waste Area Group 5 Operable Unit 5-12 Comprehensive Remedial Investigation/Feasibility Study

1. INTRODUCTION

The development and results of the Waste Area Group (WAG) 5 comprehensive remedial investigation/feasibility study (RI/FS) are presented in this report. Waste Area Group 5 comprises two operational areas, the Auxiliary Reactor Area (ARA) and the Power Burst Facility (PBF). Both operational areas are located in the south-central part of the Idaho National Engineering and Environmental Laboratory (INEEL) north of Highway 20. The locations of the ARA and PBF at the INEEL are illustrated in Figure 1-1.

1.1 Purpose

The comprehensive RI/FS is the last scheduled investigation under the Federal Facility Agreement and Consent Order (FFA/CO) (DOE-ID 1991) for WAG 5. The evaluation is a cumulative and comprehensive summary of previous investigations and additional studies conducted as part of the RI/FS to evaluate the overall potential risk posed by historical WAG 5 operations. The objectives of the WAG 5 comprehensive RI/FS are as follows:

- Identify sites for evaluation in the WAG 5 comprehensive RI/FS
- Determine the nature and extent of contamination associated with the sites identified for quantitative evaluation in the WAG 5 comprehensive RI/FS
- Determine WAG 5 site-specific transport properties through review of past investigations and the results of planned field activities
- Estimate the current and future cumulative and comprehensive baseline risk to human health and the environment posed by the contaminants of potential concern (COPCs) at WAG 5 sites
- Conduct literature searches and interviews and review results of past investigations to develop and evaluate candidate remedial technologies for WAG 5 sites
- Develop and evaluate the appropriate remedial alternatives based on nine Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC § 9601 et seq.) criteria for the sites identified for potential remediation at WAG 5.

Ultimately, the risk assessment and evaluation of alternatives will be summarized in a proposed plan that will be disseminated to stakeholders to support selecting final remedial alternatives for WAG 5. A record of decision (ROD) will be developed to document the selected remedies. Therefore, the most critical purpose of the RI/FS is to provide sufficient information to regulatory agencies and all other stakeholders for remedial decision making.

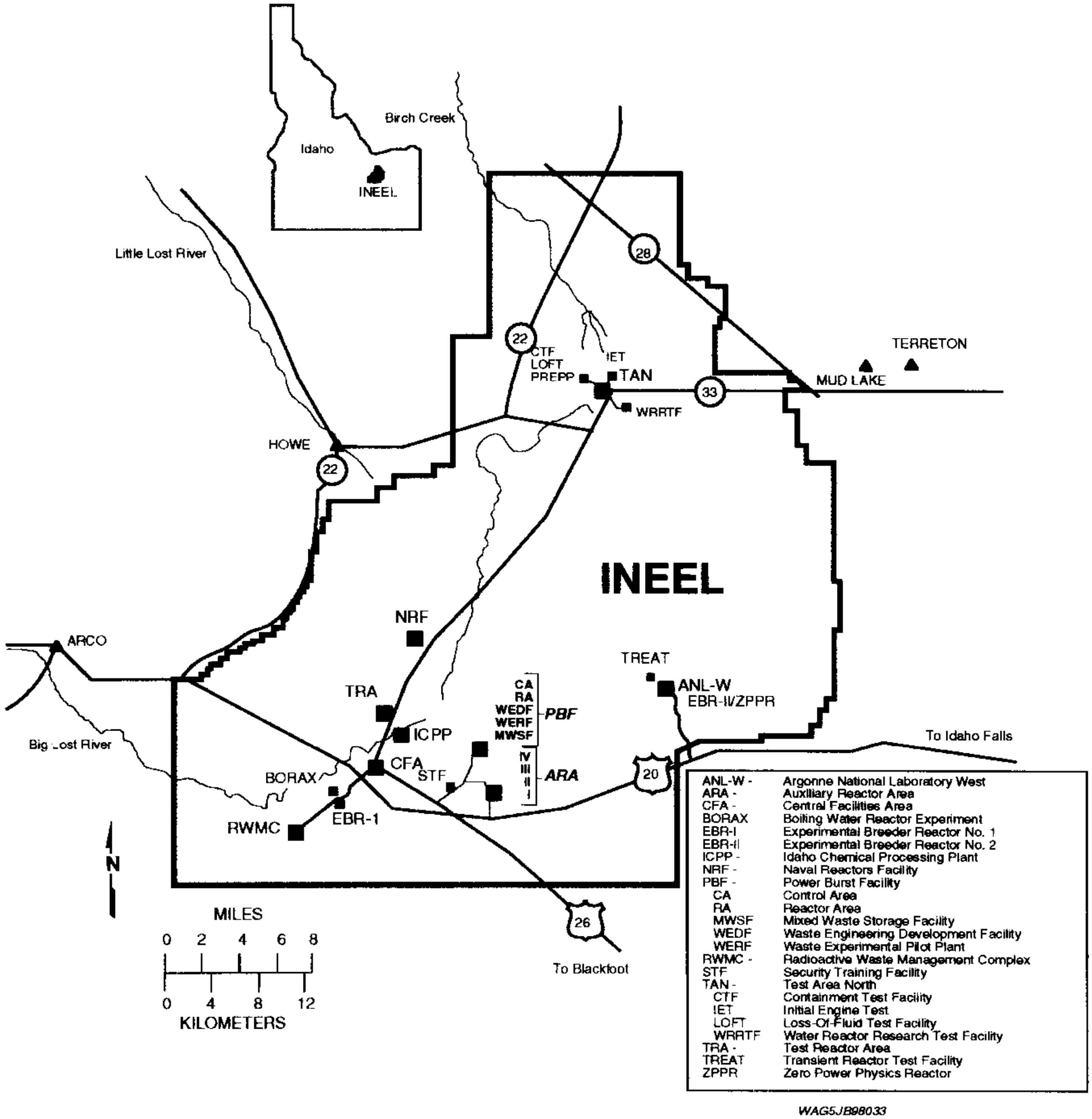

Figure 1-1. The Idaho National Engineering and Environmental Laboratory showing the locations of the Auxiliary Reactor Area and the Power Burst Facility.

1.2 Scope

The RI/FS report was developed in two stages: (1) a remedial investigation (RI), which includes a baseline human health and ecological risk assessment (BRA), and (2) a feasibility study (FS) that examines potential remedial alternatives to adequately mitigate the risks identified in the RI/BRA. Two separate documents, an RI/BRA and an FS, were developed in parallel and combined into one final WAG 5 comprehensive RI/FS report. Facility histories, physical characteristics of the sites, the nature and extent of contamination, and contaminant fate and transport are examined and reported in the RI in the support and development of both phases of the RI/FS.

In the WAG 5 RI/BRA, potential risks are evaluated under postulated scenarios with no remediation applied to mitigate the potential risks. The physical and historical settings for the sites within WAG 5 are defined, and estimates of potential human health and ecological risks associated with the ARA and the PBF are developed. The nature and extent of contamination are evaluated through the interpretation of analytical results from environmental media. Limited fate and transport modeling is performed for selected sites based on their potential to contaminate groundwater. Carcinogenic and noncarcinogenic human health risks are assessed using a deterministic approach, and a qualitative uncertainty analysis describes the potential for overestimating or underestimating risks. An ecological risk assessment addresses potential impacts to environmental receptors.

In the WAG 5 FS, remedial action objectives and preliminary remediation goals to meet those objectives are developed. Available remedial technologies are identified and a preliminary screening of technologies is applied to determine candidate remedial alternatives for WAG 5 sites. A qualitative evaluation of candidate remedial actions against the CERCLA criteria (42 USC § 9601 et seq.) is implemented to determine which remedial alternatives should be investigated in detail. The reduced list of alternatives comprises remedial alternatives evaluated in a detailed analysis against seven of the nine CERCLA criteria. The detailed analysis of alternatives will be used to develop preferred alternatives in the WAG 5 comprehensive RI/FS proposed plan and address the final two CERCLA criteria.

1.3 Regulatory Background

In January 1986, hazardous waste disposal sites within the INEEL that might pose an unacceptable risk to human health and safety or the environment were identified in the results of an INEEL assessment (EG&G 1986). The sites were ranked using either the U.S. Environmental Protection Agency (EPA) hazard ranking system for sites with chemical contamination or the U.S. Department of Energy (DOE) modified hazard ranking system for sites with radiological contamination. A score of 28.5 or higher in either category qualifies a site for the National Priorities List (NPL) as amended by CERCLA (42 USC § 9601 et seq.). Because several sites within the INEEL received scores in excess of 28.5, the entire reservation became a candidate for the NPL. Six individual sites within ARA were scored. The maximum modified hazard ranking system score was 13.7, and the highest hazard ranking score was 10.5 (EG&G 1986). Seven PBF sites received scores. The highest modified hazard ranking system score was 4.2, and the largest hazard ranking score was 12.0 (EG&G 1986).

On July 28, 1986, the U.S. Department of Energy Idaho Operations (DOE-ID) entered into a Consent Order and Compliance Agreement (COCA) with Region 10 of the EPA and the U.S. Geological Survey (DOE-ID 1986). The agreement called for implementing an action plan to remediate active and inactive waste disposal sites at the INEEL under the authority of the Resource Conservation and Recovery Act (RCRA) (42 USC § 6901 et seq.), which regulates the generation, transportation, treatment, storage, and disposal of hazardous waste. The sites identified for further evaluation during the INEEL installation assessment (EG&G 1986), including those located within WAG 5, were covered by the COCA.

On November 15, 1989, the EPA added the INEEL to the NPL under CERCLA (42 USC § 9601 et seq.), also known as the Superfund Act. The NPL identifies high-priority sites for investigation and remediation. The Superfund Act also requires providing the public with opportunities to participate in the decision-making process. The decision to add the INEEL to the NPL was based on the detection of contaminants in the environment at INEEL sites.

The FFA/CO and its associated Action Plan (DOE-ID 1991) were negotiated and signed by DOE-ID, EPA, and the Idaho Department of Health and Welfare (IDHW) in December 1991 to implement the remediation of the INEEL under CERCLA. Effective December 9, 1991, the FFA/CO superseded the COCA. The goals of the FFA/CO are to ensure that (1) potential or actual INEEL releases of contaminants to the environment are thoroughly investigated in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR 300) and (2) appropriate response actions are taken to protect human health and the environment. The FFA/CO established the procedural framework and schedule for developing, prioritizing, implementing, and monitoring response actions at the INEEL in accordance with CERCLA and RCRA legislation and the Idaho Hazardous Waste Management Act. The FFA/CO is consistent with a general approach approved by the EPA and DOE in which agreements with states as full partners would allow site investigation and cleanup to proceed using a single road map to minimize conflicting requirements and maximize limited remediation resources. For management purposes, the FFA/CO divided the INEEL into 10 WAGs.

The Secretary of Energy's policy statement on the National Environmental Policy Act (NEPA) (DOE 1994) stipulates that DOE will rely on the CERCLA process for review of actions to be taken under CERCLA. The policy statement also requires that DOE address NEPA values and public involvement procedures by incorporating NEPA values, to the extent practicable, in documents and public involvement activities generated under CERCLA.

In the FFA/CO Action Plan (DOE-ID 1991), potential source areas (sites) within each WAG were assigned to an operable unit (OU) for investigation or remedial activities. The assignments were designed to match the rigor of the assessment process with the complexity of each site and to allow for flexibility in determining appropriate further action as each assessment or action was completed. Waste Area Group 5 was subdivided into 13 OUs, originally containing a total of 48 individual sites. Subsequent to the publication of the FFA/CO, six additional sites were formally assigned to OUs within WAG 5. During the development of the RI/FS one more potential site was identified. In total, 55 sites are incorporated in Operable Unit 5-12, which is the comprehensive RI/FS for WAG 5.

1.4 Report Organization

The WAG 5 comprehensive RI/FS report comprises the two major components, the RI/BRA and the FS. The RI/BRA consists of eight sections, with Section 1 containing introductory material pertinent to both the RI/BRA and the FS. Four sections comprise the FS. Each section begins with a table of contents and ends with a list of documents referenced in the section. The report format is adapted from the RI/FS outline suggested by the EPA (EPA 1988). A summary of each section is provided below:

- Section 2—The general historical background and physical characteristics of WAG 5, such as topography, meteorology, geology, hydrology, archeological resources, demography, and ecology, are described.

- Section 3—Summary descriptions of the 55 sites in WAG 5 are provided, including their respective investigations, the actions taken, decisions reached, deviations from the WAG 5 Work Plan (DOE-ID 1997), and any other information pertinent to the BRA. The quality assurance and quality control results for samples collected and analyzed under the WAG 5 Work Plan (DOE-ID 1997) are analyzed, and an assessment of proximal facilities is summarized. Site and contaminant screening to identify those sites retained for quantitative evaluation in the BRA are presented.

- Section 4—The nature and extent of contamination are addressed for sites retained for the human health component of the BRA. Site characterization includes the development of waste, concentrations, physical characteristics, and other parameters pertinent to define source terms in each medium of interest. Also, site groupings for the cumulative risk assessment are defined.

- Section 5—A contaminant fate and transport discussion is presented that supports the evaluation of human health risk via groundwater exposure pathways.

- Section 6—The methodology applied in the human health risk evaluation is summarized. Supporting discussions about contaminant screening and the development of exposure assessment, media concentrations, quantification of exposures, toxicity assessment, risk characterization, and a qualitative uncertainty analysis are included.

- Section 7—The ecological risk assessment (ERA) for WAG 5 is provided. Risk assessment methodology and the results are presented. The ERA develops site and contaminant screening, the nature and extent of contamination, and risk characterization independently from the human health risk assessment.

- Section 8—A summary of the risk assessment and conclusions to focus the feasibility study are presented.

- Section 9—Assumptions incorporated into the FS are listed. Remedial action objectives and preliminary remediation goals are developed, followed by the identification of appropriate general response actions and preliminary technology screening.

- Section 10—Based on the technology screening in Section 9, the candidate remedial alternatives for WAG 5 sites are developed.

- Section 11—The candidate remedial alternatives are described and qualitatively evaluated against the CERCLA criteria. Those alternatives that meet minimum requirements are identified for detailed analysis.

- Section 12—The remedial alternatives are analyzed in detail against the CERCLA criteria, and the relative advantages and disadvantages of the various alternatives are compared.

Supporting data for the RI/BRA are documented in appendices. The list of appendices follows:

- Appendix A—Media Concentrations for Risk Assessment

- Appendix B—Human Health Risk Assessment Tables

- Appendix C—Facilities Assessment Analysis

- Appendix D—GWSCREEN Output Files
- Appendix E—Analytical Results and Data Quality for Samples Collected Under the WAG 5 Comprehensive RI/FS Work Plan
- Appendix F—WAG 5 Fauna and Functional Groups
- Appendix G—Ecological Evaluation Toxicity Reference Values
- Appendix H—Development of Bioaccumulation Factors for Metals
- Appendix I—Ecological Dose Calculations
- Appendix J—Previously Unpublished Engineering Design Files
- Appendix K—Cost Estimates for the Feasibility Study
- Appendix L—Evaluation of Site ARA-25.

1.5 References

42 USC § 6901 et seq., *United States Code*, October 21, 1976, "Resource Conservation and Recovery Act."

42 USC § 9601 et seq., *United States Code*, December 11, 1980, "Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA/Superfund)."

40 CFR 300, *Code of Federal Regulations*, Title 40, "Protection of the Environment," Part 300, "National Oil and Hazardous Substances Pollution Contingency Plan."

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DOE-ID, May 1997, *Work Plan for Waste Area Group 5 Operable Unit 5-12 Comprehensive Remedial Investigation/Feasibility Study,* DOE/ID-10555, Rev. 0, U.S. Department of Energy, Idaho Operations Office.

EG&G, January 1986, *Installation Assessment Report for EG&G Idaho, Inc., Operations at the Idaho National Engineering Laboratory,* EGG-WM-6875, EG&G Idaho, Inc.

EPA, October 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA,* Interim Final, EPA/540/G-89/004, U.S. Environmental Protection Agency.

2. Site Background and Physical Description

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2. SITE BACKGROUND AND PHYSICAL DESCRIPTION

The INEEL, originally established in 1949 as the National Reactor Testing Station (NRTS), is a DOE-managed reservation that historically has been devoted to energy research and related activities. The NRTS was redesignated as the Idaho National Engineering Laboratory (INEL) in 1974 to reflect the broad scope of engineering activities that was being conducted at various laboratory facilities. In 1997, the INEL was redesignated as the Idaho National Engineering and Environmental Laboratory (INEEL) in keeping with contemporary emphasis on environmental research.

Historical testing at the INEEL demonstrated that nuclear power could be used to safely generate electricity and for other peaceful applications. More nuclear reactors and types of reactors have been built at the INEEL than at any other single location in the world. Currently, only two INEEL reactors are operational, the Advanced Test Reactor at the Test Reactor Area (TRA) and the Power Burst Facility Reactor at the Power Burst Facility (PBF). The PBF Reactor is on standby and has not been operated since 1985. In December 1997, the PBF Reactor was designated as a fuel storage area. The remaining reactors have been phased out because their missions were completed (Irving 1993). Spent nuclear fuel management, hazardous and mixed waste management and minimization, cultural resources preservation, and environmental engineering, protection, and remediation are challenges addressed by current INEEL activities (DOE-ID 1996). Environmental restoration and waste management issues are the focus of current research.

Three federal government contractors operate the INEEL: Lockheed Martin Idaho Technologies Company (LMITCO), Westinghouse Electric Corporation, and Argonne National Laboratory-West (ANL-W). The contractors, LMITCO, Westinghouse, and ANL-W, conduct various programs at the INEEL under the supervision of three DOE offices, DOE-ID, the Pittsburgh Naval Reactors Office, and the Chicago Operations Office, respectively. Westinghouse operates the Naval Reactors Facility (NRF), designated as WAG 8, and Argonne operates the ANL-W facility, designated as WAG 9. The prime operating and Site-services contractor for the INEEL, LMITCO, is responsible for the operation of all other facilities. Also responsible for the remaining eight WAGs and Site-wide management, LMITCO provides a variety of programmatic and support services related to nuclear reactor design and development, nonnuclear energy development, materials testing and evaluation, operational safety, radioactive waste management, and environmental restoration. A National Environmental Research Park has been established in the central portion of the INEEL, which allows comparative studies of ecological processes in sagebrush-steppe ecosystems.

2.1 Location and Description

The INEEL is located in southeastern Idaho (Figure 1-1) and occupies 2,305 km^2 (890 mi^2) in the northeastern region of the Snake River Plain. Regionally, the INEEL is nearest to the cities of Idaho Falls and Pocatello and to U.S. Interstate Highways I-15 and I-86 (see Figure 2-1). The Site area is nearly 63 km (39 mi) long from north to south and about 58 km (36 mi) wide in its broadest southern portion, and occupies portions of five southeast Idaho counties: Butte, Bingham, Bonneville, Jefferson, and Clark. As shown in Figure 2-1, most of the INEEL lies within Butte County. Approximately 95% of the land within the INEEL has been withdrawn from the public domain. The remaining 5% includes public highways (U.S. 20 and 26 and Idaho 22, 28, and 33) and the Experimental Breeder Reactor I, which is a national historic landmark (Irving 1993).

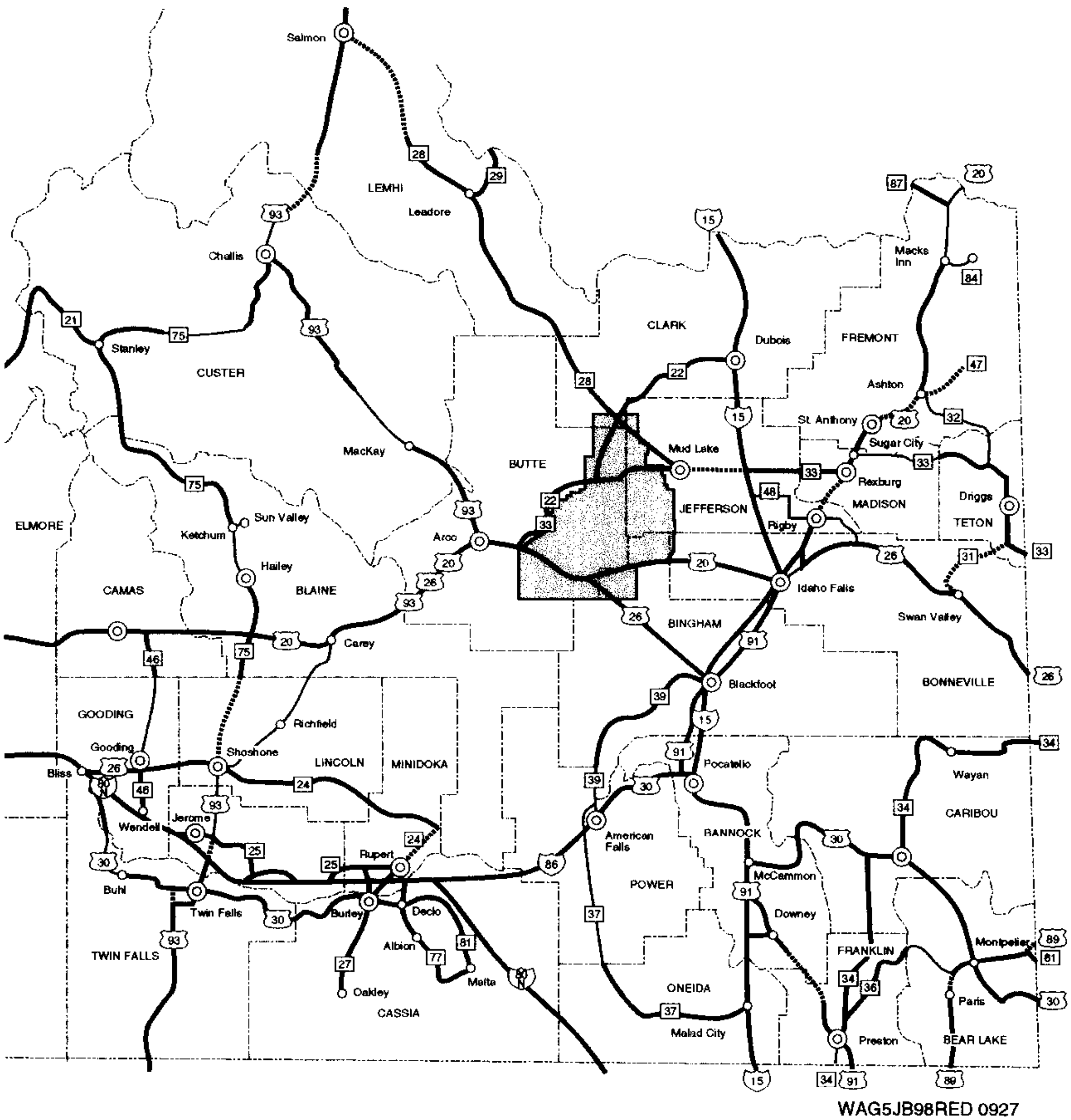


Figure 2-1. Counties adjacent to the INEEL.

The surface of the INEEL is a relatively flat, semiarid, sagebrush desert. The predominant relief is manifested either as volcanic buttes jutting from the desert floor or as unevenly surfaced basalt flows, flow vents, and fissures. With the exception of the buttes on the southern border of the INEEL (see Section 2.2.1), elevation levels on the INEEL range from 1,460 m (4,790 ft) in the south to 1,802 m (5,913 ft) in the northeast, with an average elevation of 1,524 m (5,000 ft) above sea level (Irving 1993).

Figure 2-2 shows mountain ranges bordering the INEEL and streams draining intermountain valleys near the INEEL. In the western portion of the INEEL, intermittently flowing waters from the Big Lost River flow to the Lost River Sinks in the northwestern portion of the INEEL. Water either evaporates or infiltrates into the Snake River Plain Aquifer (SRPA) at the sinks. Normally, water is diverted for irrigation before reaching the INEEL and flows onto the Site only when sufficient snow pack provides spring runoff. Within the southern portion of the INEEL, flow from the Big Lost River can be diverted to Spreading Areas A, B, C, and D, west and southwest of the Radioactive Waste Management Complex (RWMC). A system to divert flow to these areas was constructed in 1958 to protect INEEL facilities from potential flooding. Infiltration to the SRPA occurs at the spreading areas when water is diverted to them (Barraclough, Robertson, and Janzer 1976; Wood 1989). Runoff from the Birch Creek drainage is diverted for hydropower but may be released in the spring in sufficient quantities to move onto the INEEL via a canal. Surface water flowing onto the INEEL via these drainages terminates on the INEEL.

Agricultural lands, U.S. Forest Service lands, and U.S. Bureau of Land Management (BLM) lands that are managed as rangeland surround the INEEL. Irrigated farmlands exist adjacent to approximately 25% of the INEEL boundary (Becker et al. 1996). Lands acquired for the NRTS originally were controlled by the BLM and were withdrawn through public land orders in 1946, 1949, and 1950. Until these withdrawals, the land was used primarily as rangeland. From 121,410 to 141,645 ha (300,000 to 350,000 acres) within the perimeter of the INEEL have been open to grazing through permits administered by the BLM. Since 1957, approximately 1,386 km^2 (535 mi^2) in the central portion of the INEEL have been maintained as a grazing exclusion area. Historically, portions of this central core have been used as bombing and gunnery ranges. Currently, the largely undeveloped central portion of the INEEL is reserved for ecological studies of sagebrush-steppe ecosystems. Figure 2-3 illustrates land ownership in the vicinity of the INEEL.

The INEEL has nine distinct and geographically separate functional facilities corresponding to nine WAGs, as illustrated in Figure 2-4. Each area serves or has served a particular programmatic or support activity. As governed by the FFA/CO (DOE-ID 1991), the remedial evaluations for each facility area must address impacts to the SRPA generated by operations within the WAG, with the remaining portions of the SRPA across the INEEL addressed by the Site-wide waste area group, WAG 10 (DOE-ID 1991). Any portions of the SRPA that may be impacted by WAG 5 operations are included in the WAG 5 remedial investigation.

Comprising the ARA and PBF, WAG 5 is in the south-central portion of the Site. The ARA consists of four separate operational areas designated as ARA-I, ARA-II, ARA-III, and ARA-IV. The ARA-I, -II, and -III facilities are no longer used and are currently in varying states of decontamination and dismantlement (D&D). The ARA-IV facility was decontaminated and decommissioned in 1984 and 1985 but still serves as a testing area for explosives. The PBF, once known as the Special Power Excursion Reactor Test (SPERT) facilities, consists of five separate operational areas: the PBF Control Area, the PBF Reactor Area (SPERT-I), the Waste Engineering Development Facility (WEDF) (SPERT-II), the Waste Experimental Reduction Facility (WERF) (SPERT-III), and the Mixed Waste Storage Facility (MWSF) (SPERT-IV). Figures 2-5 and 2-6 illustrate the physical configurations of the two areas and the WAG 5 sites evaluated under the FFA/CO.

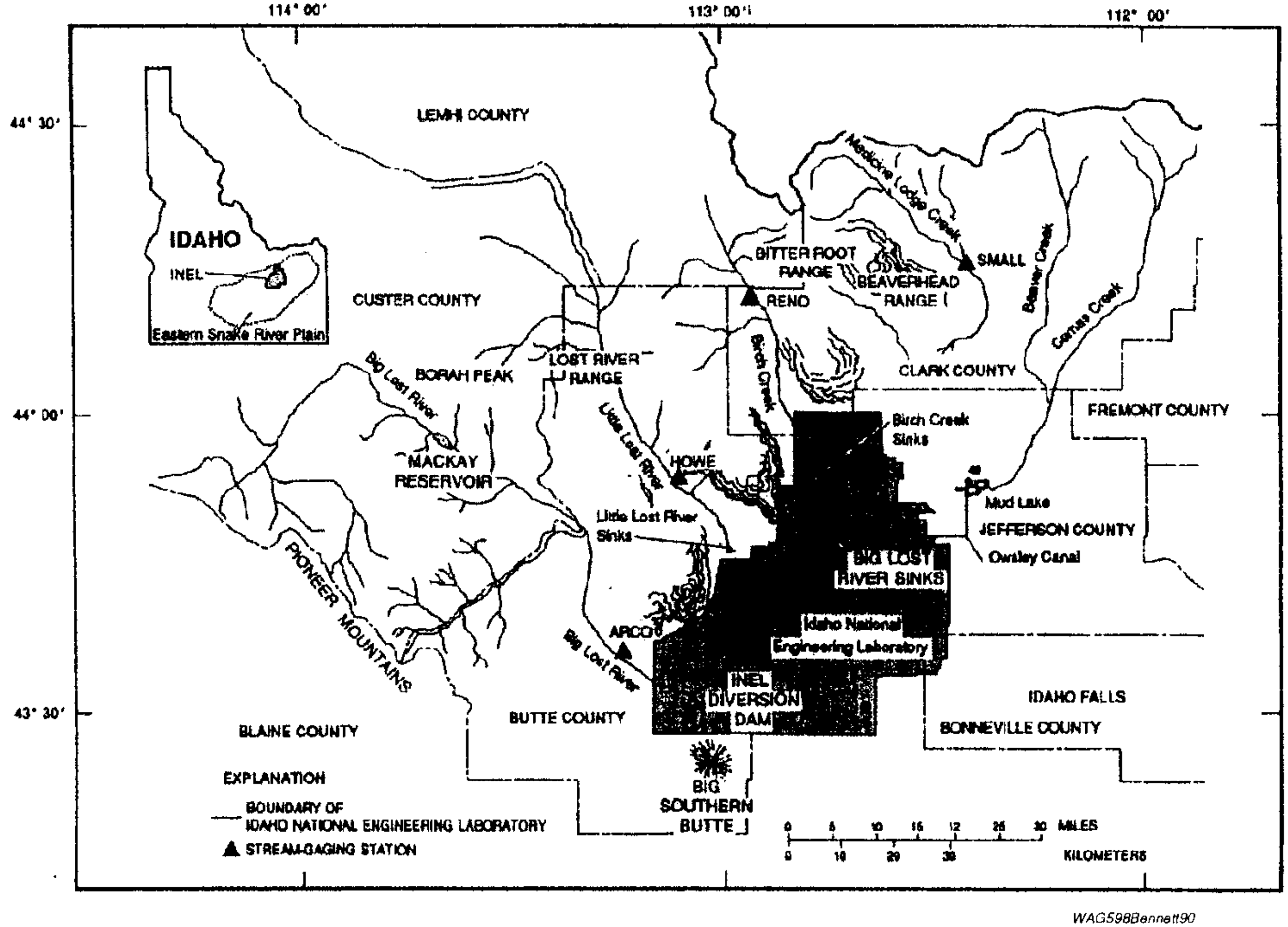


Figure 2-2. Mountain ranges and streams draining intermountain valleys near the INEEL (Bennett 1990).

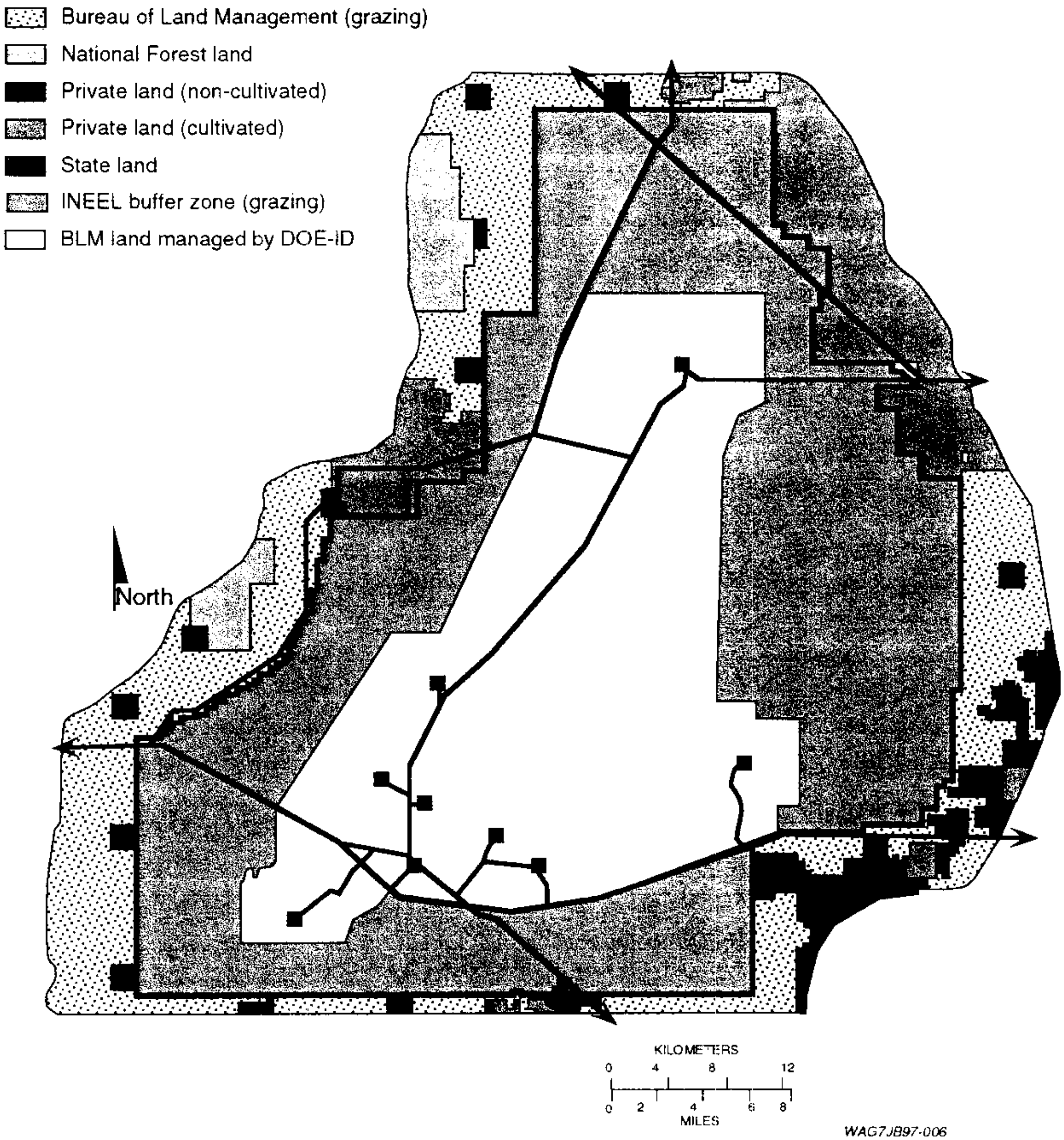


Figure 2-3. Land ownership distribution in the vicinity of the INEEL (DOE-ID 1996).

Idaho National Engineering and Environmental Laboratory

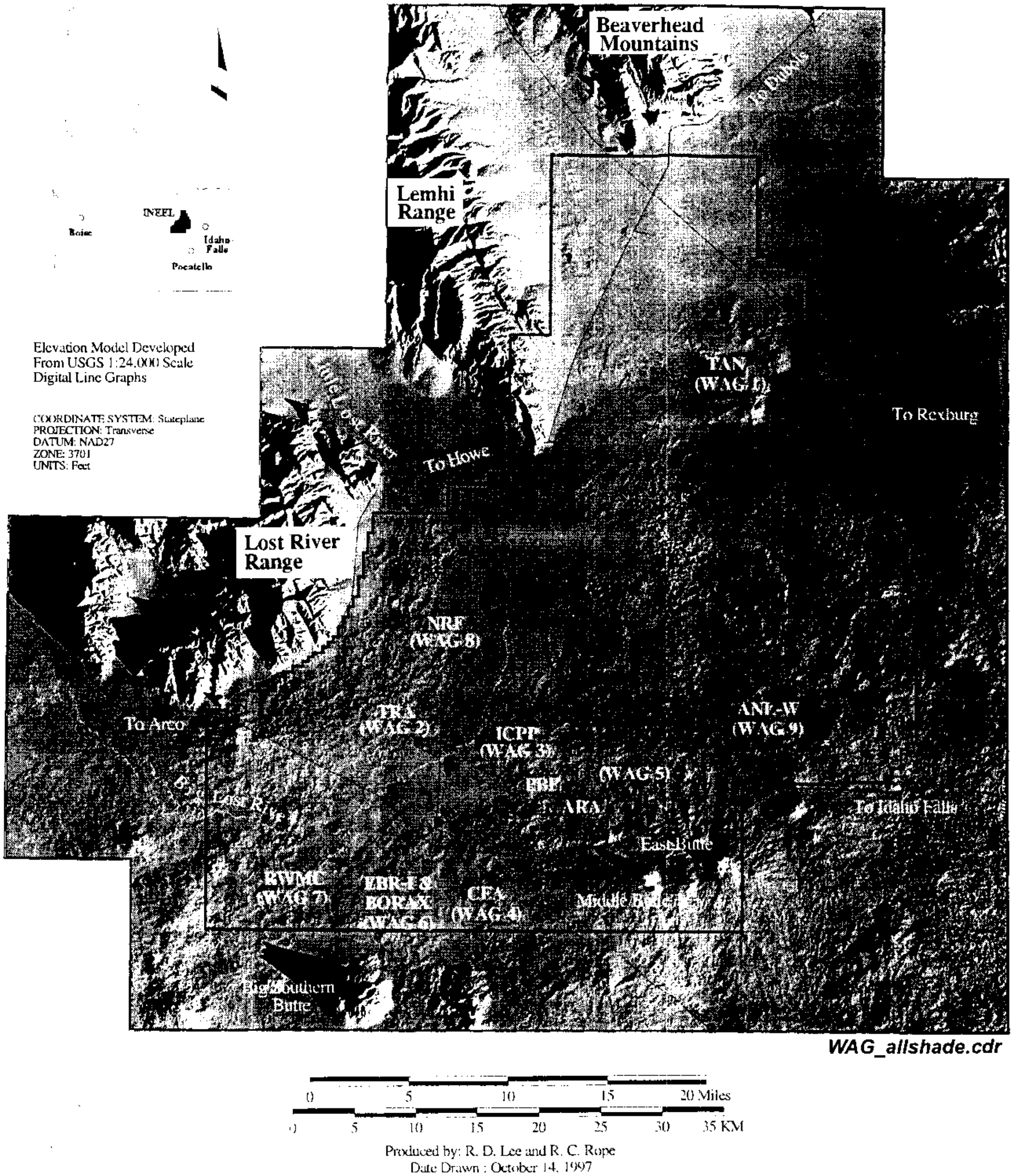
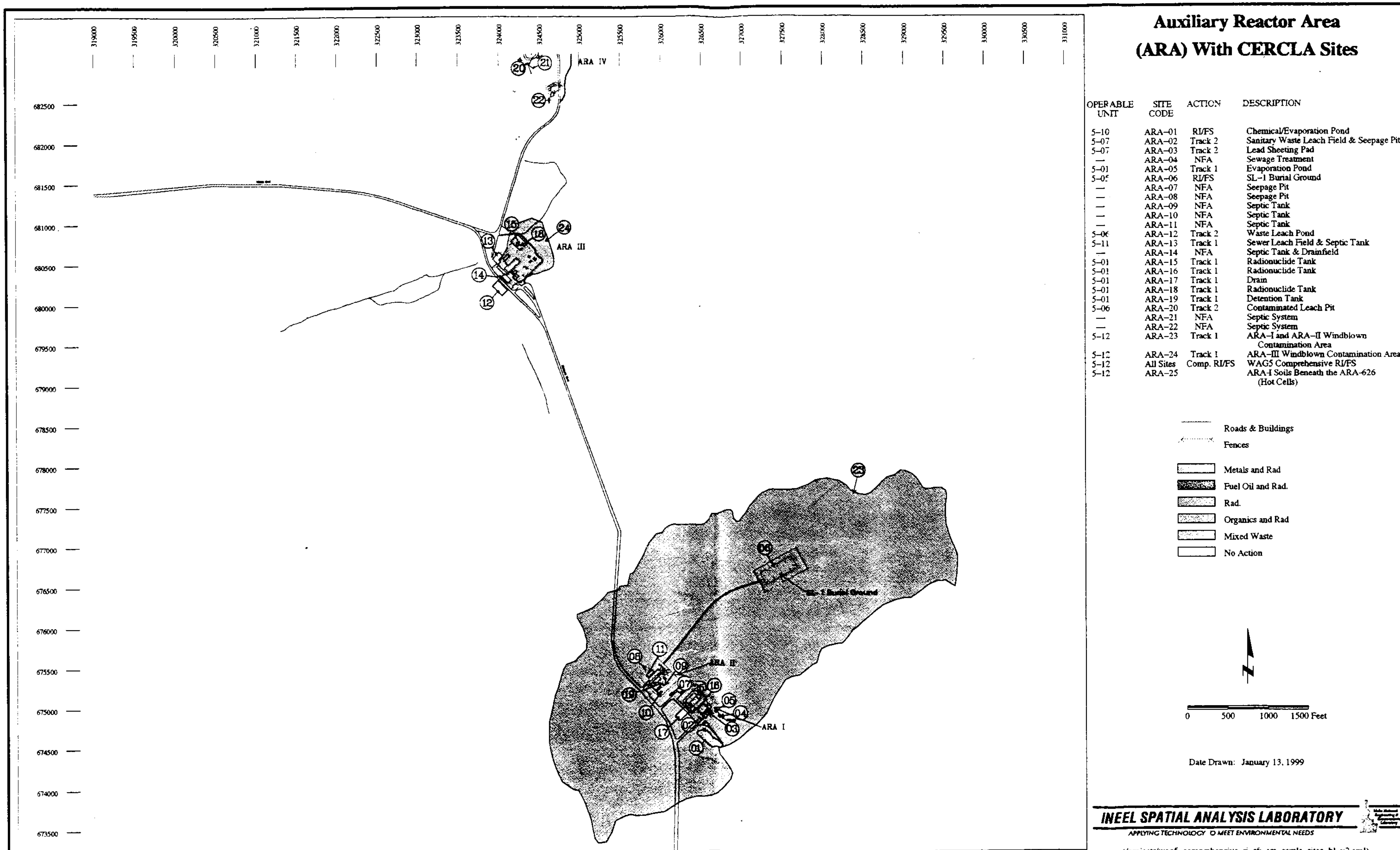
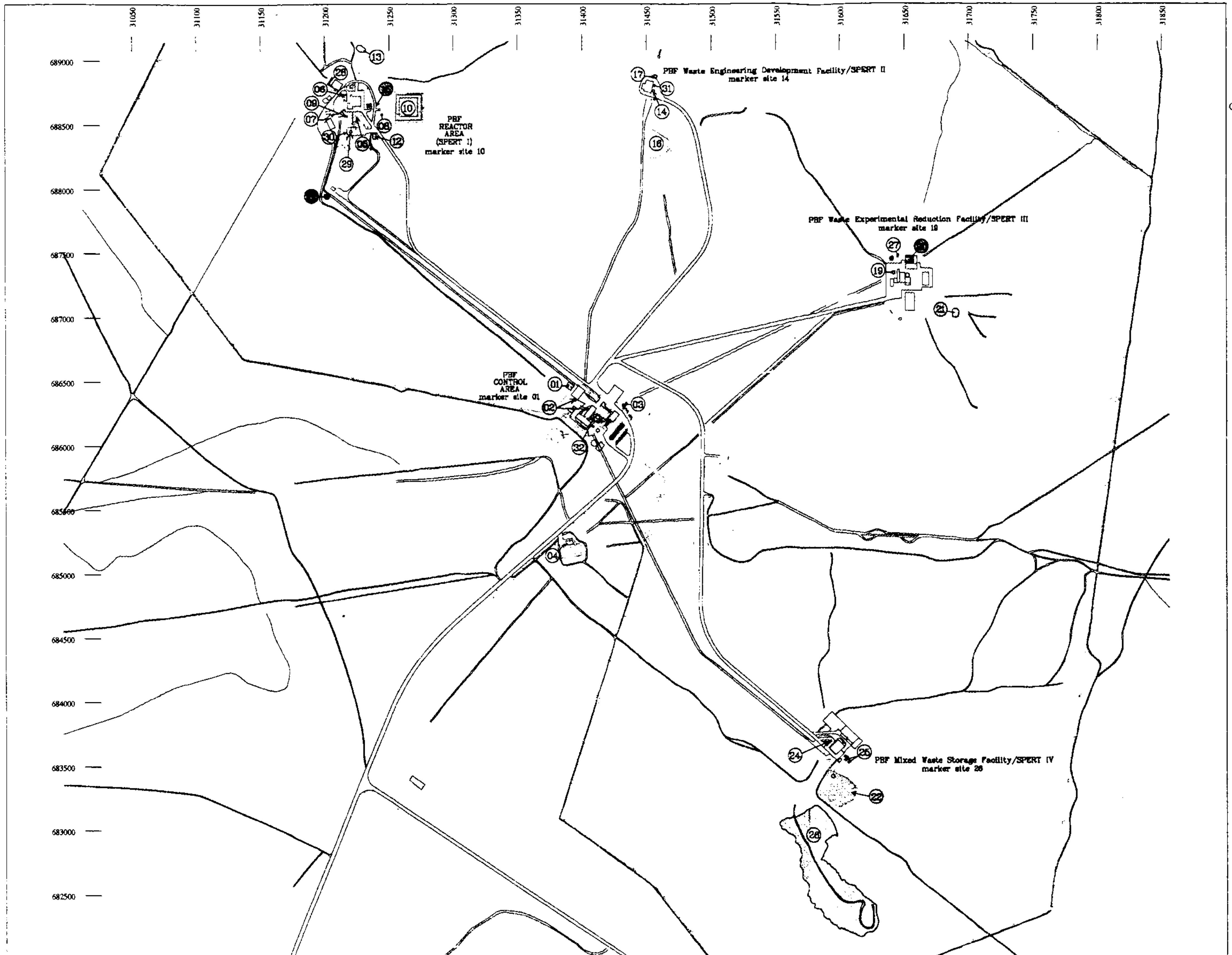


Figure 2-4. Location of the INEEL in southeastern Idaho, topographic features, and INEEL facilities.



OPERABLE UNIT	SITE CODE	ACTION	DESCRIPTION
5-10	ARA-01	RI/FS	Chemical/Evaporation Pond
5-07	ARA-02	Track 2	Sanitary Waste Leach Field & Seepage Pit
5-07	ARA-03	Track 2	Lead Sheeting Pad
—	ARA-04	NFA	Sewage Treatment
5-01	ARA-05	Track 1	Evaporation Pond
5-05	ARA-06	RI/FS	SL-1 Burial Ground
—	ARA-07	NFA	Seepage Pit
—	ARA-08	NFA	Seepage Pit
—	ARA-09	NFA	Septic Tank
—	ARA-10	NFA	Septic Tank
—	ARA-11	NFA	Septic Tank
5-06	ARA-12	Track 2	Waste Leach Pond
5-11	ARA-13	Track 1	Sewer Leach Field & Septic Tank
—	ARA-14	NFA	Septic Tank & Drainfield
5-01	ARA-15	Track 1	Radionuclide Tank
5-01	ARA-16	Track 1	Radionuclide Tank
5-01	ARA-17	Track 1	Drain
5-01	ARA-18	Track 1	Radionuclide Tank
5-01	ARA-19	Track 1	Detention Tank
5-06	ARA-20	Track 2	Contaminated Leach Pit
—	ARA-21	NFA	Septic System
—	ARA-22	NFA	Septic System
5-12	ARA-23	Track 1	ARA-I and ARA-II Windblown Contamination Area
5-12	ARA-24	Track 1	ARA-III Windblown Contamination Area
5-12	All Sites	Comp. RI/FS	WAG5 Comprehensive RI/FS
5-12	ARA-25		ARA-I Soils Beneath the ARA-626 (Hot Cells)

Figure 2-5. The physical configuration of the Auxiliary Reactor Area.



Power Burst Facility (PBF) With CERCLA Sites

OPERABLE UNIT	SITE CODE	ACTION	DESCRIPTION
—	PBF-01	NFA	Septic Tank
—	PBF-02	NFA	Septic Tanks & Seepage Pit
—	PBF-03	NFA	Septic Tank & Seepage Pit
5-04	PBF-04	Track 1	Oil Tank
5-08	PBF-05	Track 2	Warm Waste Injection Well
5-03	PBF-06	Track 1	Blowdown Pit
5-03	PBF-07	Track 1	Oil Drum Storage
5-13	PBF-08	Inter. Action	Corrosive Waste Disposal Sump Brine Tank
—	PBF-09	NFA	Septic Tank & Drainfield
5-13	PBF-10	Inter. Action	Evaporation Pond
5-08	PBF-11	Track 2	Seepage Pit
5-02	PBF-12	Track 1	Leach Pond
5-03	PBF-13	Track 1	Rubble Pit
5-03	PBF-14	Track 1	Inactive Fuel Oil Tank
5-08	PBF-15	Track 2	Corrosive Waste Injection Well
5-09	PBF-16	Track 2	Leach Pond
—	PBF-17	NFA	Septic Tank & Seepage Pit
5-01	PBF-19	Track 1	Inactive Fuel Oil Tank
5-09	PBF-20	Track 2	Small Leach Pond
5-02	PBF-21	Track 1	Large Leach Pond
5-09	PBF-22	Track 2	Leach Pond
5-03	PBF-24	Track 1	Blowdown Pit
—	PBF-25	NFA	Septic Tank & Leach Pit
5-02	PBF-26	Track 1	SPERT Lake
—	PBF-27	NFA	Septic Tank & Seepage Pit
5-03	PBF-28	Track 1	Cooling Tower Area & Drainage Ditch
5-12	PBF-29	Track 1	PBF Reactor Area Abandoned Fuel Oil Tank
5-12	PBF-30	Track 1	PBF Reactor Area Abandoned Septic System
5-12	PBF-31	Track 1	SPERT II Fuel Oil Tank
5-12	PBF-32	Track 1	PBF Control Area Fuel Oil Tank
5-12	All Sites Comp.	RI/FS	WAG5 Comprehensive RI/FS

Roads & Buildings

Fences

Metals and Rad

Metals

Fuel Oil

Rad.

Acids

Organics and Rad

No Action

0 500 1000 1500 Feet

Date Drawn: January 13, 1999

INEEL SPATIAL ANALYSIS LABORATORY

APPLYING TECHNOLOGY TO MEET ENVIRONMENTAL NEEDS

(/projects/wag5_comprehensive_n_sf: pbf_cercla_sites-bl_v1.aml)

Figue 2-6. The physical configuration of the Power Burst Facility.

2.2 Physical Characteristics

The physical features of the ARA and PBF areas are generally consistent with those described below for the INEEL. Unique features specific to WAG 5 also are summarized.

2.2.1 Physiography

The INEEL is located on the Eastern Snake River Plain (ESRP), the largest continuous physiographic feature in southern Idaho. This large topographic depression extends from the Oregon border across Idaho to Yellowstone National Park and northwestern Wyoming. With the exception of the buttes on the southern border of the INEEL (see below), the ESRP, the easternmost extension of the Columbia River Plateau Province (EG&G 1988), slopes upward from an elevation of about 762 m (2,500 ft) at the Oregon border to approximately 2,000 m (6,600 ft) at Henry's Lake near the Montana-Wyoming border (Becker et al. 1996).

The INEEL is located entirely on the northern portion of the ESRP and adjoins the Lost River, Lemhi, and Beaverhead mountain ranges to the northwest, which compose the northern boundary of the plain. The portion of the Snake River Plain occupied by the INEEL may be divided into three minor physical provinces: a central trough that extends through the INEEL from the southwest to the northeast and two flanking slopes that descend to the trough, one from the mountains to the northwest and the other from a broad lava ridge on the plain to the southeast. The slopes on the northwestern flank of the trough are mainly alluvial fans originating from sediments of Birch Creek and the Little Lost River. Also forming these gentle slopes are basalt flows that spread onto the plain. The land forms on the southeast flank of the trough were created by basalt flows that spread from an eruption zone that extends northeastward from Cedar Butte. The lavas that erupted along this zone built up a broad topographic swell directing the Snake River to its current course along the southern and southeastern edges of the plain. The ridge effectively separates the drainage of mountain ranges northwest of the INEEL from the Snake River. Big Southern Butte and the Middle and East buttes are aligned roughly along the eruption zone; however, they were formed by viscous rhyolitic lavas extruded through the basaltic cover and are slightly older than the surface basalts of the plain.

With the exception of the buttes on the southern border of the INEEL (see Figure 2-4), elevations on the INEEL range from 1,460 m (4,790 ft) in the south to 1,802 m (5,913 ft) in the northeast with an average elevation of 1,524 m (5,000 ft) above sea level (EG&G 1988). The East, Middle, and Big Southern buttes have elevations of 2,003 m (6,571 ft), 1,948 m (6,389 ft), and 2,304 m (7,559 ft) above sea level, respectively (VanHorn, Hampton, and Morris 1995).

The central lowland of the INEEL broadens to the northeast and joins the extensive Mud Lake Basin. The Big and Little Lost rivers and Birch Creek drain into this trough from valleys in the mountains to the north and west. The intermittently flowing waters of the Big Lost River have formed a flood plain in this trough, consisting primarily of sands and gravels. The streams intermittently flow to the Lost River Sinks, a system of playa depressions in the northern portion of the INEEL, east of the town of Howe, Idaho. There, the water evaporates, transpires, or recharges the SRPA. The sinks area covers several hundred acres, is flat, and consists of significant thicknesses of fluvial and lacustrine sediments.

2.2.2 Meteorology and Climatology

Meteorological and climatological data for the INEEL and the surrounding region are collected and compiled from several meteorological stations operated by the National Oceanic and Atmospheric Administration (NOAA) field office in Idaho Falls, Idaho. Three stations are located on the INEEL, one at the Central Facilities Area (CFA), one at Test Area North (TAN), and one at the RWMC.

2.2.2.1 Precipitation. Factors associated with the specific location of the INEEL in the ESRP, including altitude above sea level, latitude, and intermountain setting, affect the climate of the Site. Air masses crossing the plain have first traversed a mountain barrier and precipitated a large percentage of inherent moisture. Therefore, annual rainfall at the INEEL is light, and the region is classified as arid to semiarid (Clawson, Start, and Ricks 1989). Average annual precipitation at the INEEL is 22.1 cm (8.7 in.). The rates of precipitation are highest during the months of May and June and lowest in July. Normal winter snowfall occurs from November through April, though occasional snowstorms occur in May, June, and October. Snowfall at the INEEL ranges from about 17.3 cm (6.8 in.) per year to about 151.6 cm (59.7 in.) per year, and the annual average is 70.1 cm (27.6 in.) (Clawson, Start, and Ricks 1989).

2.2.2.2 Temperature. The moderating influence of the Pacific Ocean produces a climate at the INEEL that is usually warmer in the winter and cooler in summer than locations of similar latitude in the United States east of the Continental Divide. The Centennial Mountain Range and Beaverhead Mountains of the Bitterroot Range, both north of the INEEL, act as an effective barrier to the movement of most of the intensely cold winter air masses entering the United States from Canada. Occasionally, however, cold air spills over the mountains and is trapped in the plain. The INEEL then experiences below-normal temperatures usually lasting from 1 week to 10 days. The relatively dry air and infrequent low clouds permit intense solar heating of the surface during the day and rapid radiant cooling at night. These factors combine to give a large diurnal range in temperature near the ground. The average summer daytime maximum temperature is 28°C (83°F), while the average winter daytime maximum temperature is –0.6°C (31°F). During a 38-year period of meteorological records (1950 through 1988) from the CFA, temperature extremes at the INEEL varied from a low of –44°C (–47°F) in January to a high of 38°C (101°F) in July (Clawson, Start, and Ricks 1989).

2.2.2.3 Humidity. Data collected from 1956 through 1961 indicate that the average relative humidity at the INEEL ranges from a monthly average minimum of 18% during the summer months to a monthly average maximum of 55% during the winter. The relative humidity is directly related to diurnal temperature fluctuations. Relative humidity reaches a maximum just before sunrise (the time of lowest daily temperature) and a minimum in midafternoon (the time of maximum daily temperature) (Clawson, Start, and Ricks 1989).

The potential annual evaporation from saturated ground surface at the INEEL is approximately 109 cm (43 in.) with a range of 102 to 117 cm (40 to 46 in.) (Clawson, Start, and Ricks 1989). Eighty percent of this evaporation occurs between May and October. During the warmest month (July), the potential daily evaporation rate is approximately 0.63 cm/day (0.25 in./day). During the coldest months (December through February), evaporation is low and may be insignificant. Actual evaporation rates are much lower than potential rates because the ground surface is rarely saturated. Evapotranspiration by the sparse native vegetation of the Snake River Plain is estimated at between 15 to 23 cm/year (6 to 9 in./year), or four to six times less than the potential evapotranspiration. Periods when the greatest quantity of precipitation water is available for infiltration (late winter to spring) coincide with periods of relatively low evapotranspiration rates (EG&G 1981).

2.2.2.4 Wind. Wind patterns at the INEEL can be quite complex. The orientations of the surrounding mountain ranges and the ESRP play an important parts in determining the wind regime. The INEEL is in the belt of prevailing westerly winds, which are channeled within the ESRP to produce a west-southwest or southwest wind approximately 40% of the time. Local mountain valley features exhibit a strong influence on the wind flow under other meteorological conditions as well. The average midspring windspeed recorded at a height of 6 m (20 ft) at the CFA meteorological station was 9.3 mph, while the average midwinter windspeed recorded at the same location was 5.1 mph (Irving 1993).

The INEEL is subject to severe weather episodes throughout the year. Thunderstorms are observed mostly during the spring and summer. The tornado risk probability is about 7.8E-05 per year for the INEEL area (Bowman et al. 1984). An average of two to three thunderstorms occurs during each of the months from June through August (EG&G 1981). Thunderstorms are often accompanied by strong gusty winds that may produce local dust storms. Precipitation from thunderstorms at the INEEL is generally light. Occasionally, however, rain resulting from a single thunderstorm on the INEEL exceeds the average monthly total precipitation (Bowman et al. 1984).

Dust devils also are common in the region. Dust devils can entrain dust and pebbles and transport them over short distances. They usually occur on warm sunny days with little or no wind. The dust cloud may be several hundred yards in diameter and extend several hundred feet in the air (Clawson, Start, and Ricks 1989).

2.2.3 Geology

2.2.3.1 Surface and Subsurface Geology. The surface of the INEEL in general is covered by Pleistocene and Holocene basalt flows ranging in age from 300,000 to 3 million years (Hackett, Pelton, and Brockway 1986). These basalts erupted mainly from northwest-trending volcanic rift zones, marked by belts of elongated shield volcanoes and small pyroclastic cones, fissure-fed lava flows, and noneruptive fissures or small-displacement faults (Bargelt et al. 1992). A prominent geologic feature of the INEEL is the flood plain of the Big Lost River. Alluvial sediments from the Quaternary age occur in a band that extends across the INEEL from the southwest to the northeast. The alluvial deposits grade into lacustrine deposits in the Site's northern portion at which the Big Lost River enters a series of playa lakes. Paleozoic sedimentary rocks make up a small area of the INEEL along the northwest boundary. Three large silicic domes (the East, Middle, and Big Southern buttes) occur along the southern boundary of the INEEL, and a number of smaller basalt cinder cones occur across the Site. Mountains of the Lost River, Lemhi, and Bitterroot ranges that border the northwest portion of the INEEL are Cenozoic fault-block composed of Paleozoic limestones, dolomites, and shales. The fault-block ranges trend northwest-southeast, and the volcanic rifts that parallel the ranges are believed to be surface expressions of extensions of the range-front faults (Bargelt et al. 1992).

Basalt flows in the surface and subsurface at the INEEL were formed by three general methods of plains-style volcanism, which is an intermediate style between the flood basalt volcanism of the Columbia Plateau and the basaltic shield volcanism of the Hawaiian Islands (Bargelt et al. 1992). The methods are flows forming low-relief shield volcanoes, fissure-fed flows, and major tube-fed flows with other minor flow types (Bargelt et al. 1992). The very low shield volcanoes, with slopes of about 1 degree, formed in an overlapping manner. The overlapping and coalescing of flows are characteristic of the low surface relief on the ESRP (Bargelt et al. 1992). Considerable variation in texture occurs within individual basalt flows. In general, the bases of basalt flows are glassy to fine-grained and minutely vesicular. The midportions of the basalt flows are typically coarser-grained with fewer vesicles than the top or bottom of the flow. The upper portions of flows are fine-grained and highly fractured with many vesicles. This pattern is the result of rapid cooling of the upper and lower surfaces with slower cooling of the interior of the basalt flow. The massive interiors of basalt flows are sometimes jointed with vertical joints in a hexagonal pattern formed during cooling (Wood 1989).

During quiescent periods between volcanic eruptions, sediments were deposited on the surface of the basalt flows. These sedimentary deposits display a wide range of grain-size distributions depending on the mode of deposition (i.e., eolian, lacustrine, or fluvial), the type of rock from which the sediments originated, and length of transport. Because of the irregular topography of the basalt flows, sedimentary materials commonly accumulated in isolated depressions.

A number of wells have been drilled within the INEEL to monitor groundwater levels and water quality. Lithologic and geophysical logs were made for most of the wells. From these logs and an understanding of the volcanism of the Snake River Plain, it is possible to develop a reasonably comprehensive picture of subsurface geology. The INEEL is homogeneous in terms of the mode of formation and types of geologic units encountered. The exact distribution of units at any specific site, however, is highly variable. Lithology logs from ARA and PBF aquifer monitoring wells are illustrated in Figures 2-7 and 2-8. The well locations are shown in Figure 2-9.

2.2.3.2 Seismic Activity. The seismic activity of eastern Idaho is concentrated along the Intermountain Seismic Belt, which extends more than 1,287 km (800 mi) from southern Arizona through eastern Idaho to western Montana. The Idaho Seismic Zone, one of two zones in this belt, extends from the Yellowstone Plateau area westward into central Idaho. Though several large shocks have occurred in mountain rages surrounding the INEEL, earthquakes beneath the ESRP are rare and of small magnitude (Hackett, Pelton, and Brockway 1986). Minor earthquakes have occurred east and north of the INEEL on the ESRP with an average local magnitude of about 1.0 on the Richter scale (EG&G 1988). The general geologic, volcanologic, and tectonic features of the ESRP are depicted in Figure 2-10.

The largest earthquake recorded for the Idaho Seismic Zone occurred on October 28, 1983, measuring 7.3 on the Richter scale. This earthquake resulted from movement along a range-front fault. The epicenter was approximately halfway between Challis and Mackay and about 50 km (30 mi) northwest of the INEEL. The faulting broke the surface for 40 km (25 mi) along the western base of the Lost River Range. Though the earthquake was felt at the INEEL, no structural or safety-related damage occurred at any INEEL facility (EG&G 1988). The interlayering of basalt lava flows and sediment interbeds on the ESRP attenuates the ground motions from earthquakes centered in the surrounding mountains (LMITCO 1996).

The northwestern portions of the INEEL near the Lemhi and Beaverhead faults are the locations on the Site most susceptible to potential seismic activity. The ARA and PBF facilities are distant from these potential seismic sources. Furthermore, WAG 5 is located in an area dominated by basalt outcroppings, which reduces the potential for surface rupture from seismic events (Holdren et al. 1997).

2.2.3.3 Volcanic Hazard. As discussed above, the INEEL is located in a region of historical volcanic activity, typically of the nonviolent basalt volcanism variety. Five to six million years ago, explosive rhyolite volcanism occurred beneath the INEEL, but the calderas are now dead and buried beneath basalt lava flows. The youngest lava flow in the region immediately surrounding the Site erupted about 4,100 years ago from the Hell's Half Acre Lava Flow to the southeast of the INEEL. The most recent lava flows within the INEEL boundary occurred some 300,000 years ago (Hackett, Pelton, and Brockway 1986).

Renewed explosive rhyolite volcanism at the INEEL is very unlikely. Geological and geochronological data indicate an eastward progression of ESRP volcanism. The magmatic plume assumed responsible for the volcanism now is thought to lie beneath Yellowstone National Park, in which explosive rhyolite volcanism is possible. Hazards associated with falling ejecta could impact the INEEL in the remotely possible event that such an explosion occurred at the park, but basalt flows originating at Yellowstone cannot reach the INEEL because of the distance and intervening mountainous terrain (Hackett, Pelton, and Brockway 1986).

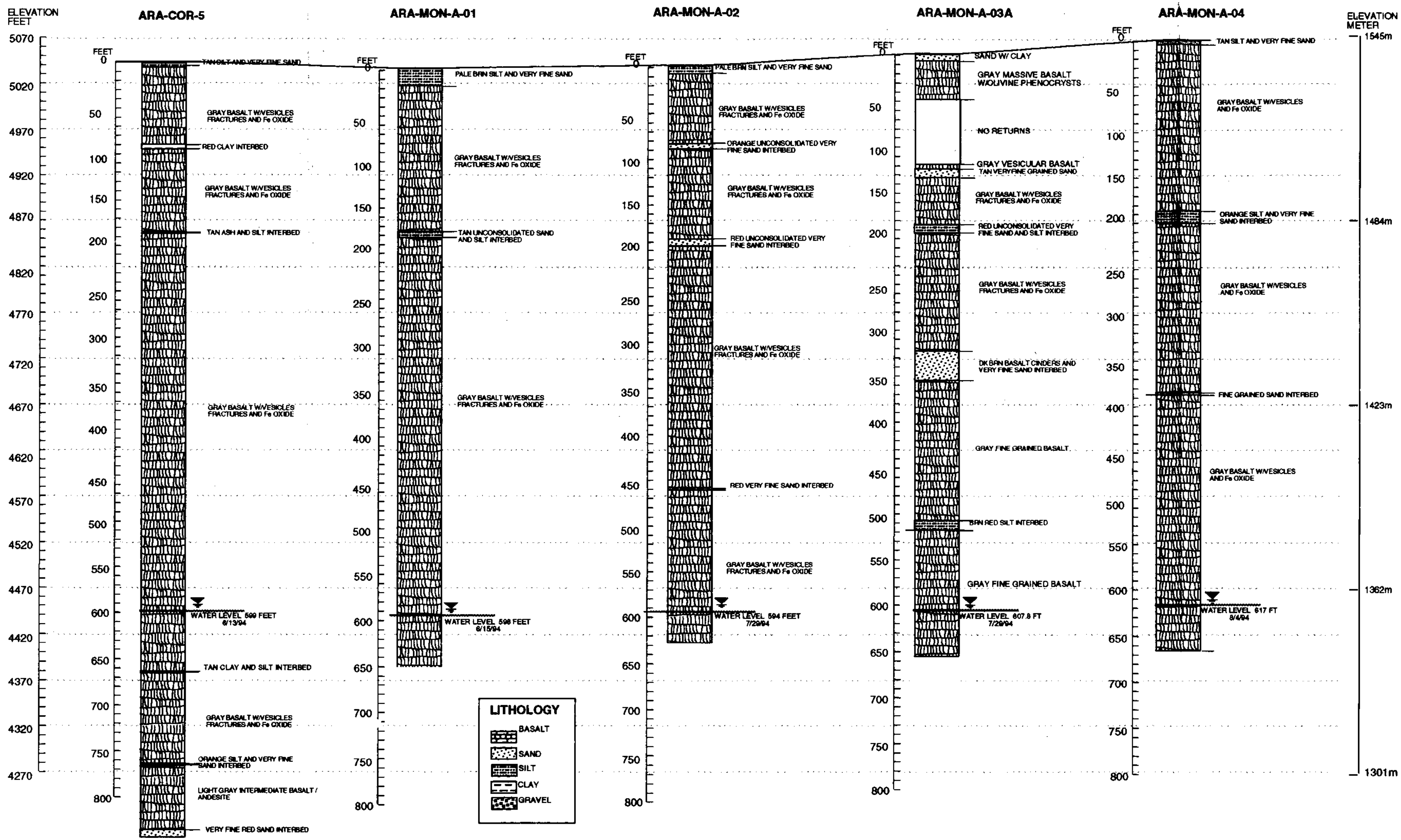


Figure 2-7. Lithology in Auxiliary Reactor Area aquifer monitoring wells.

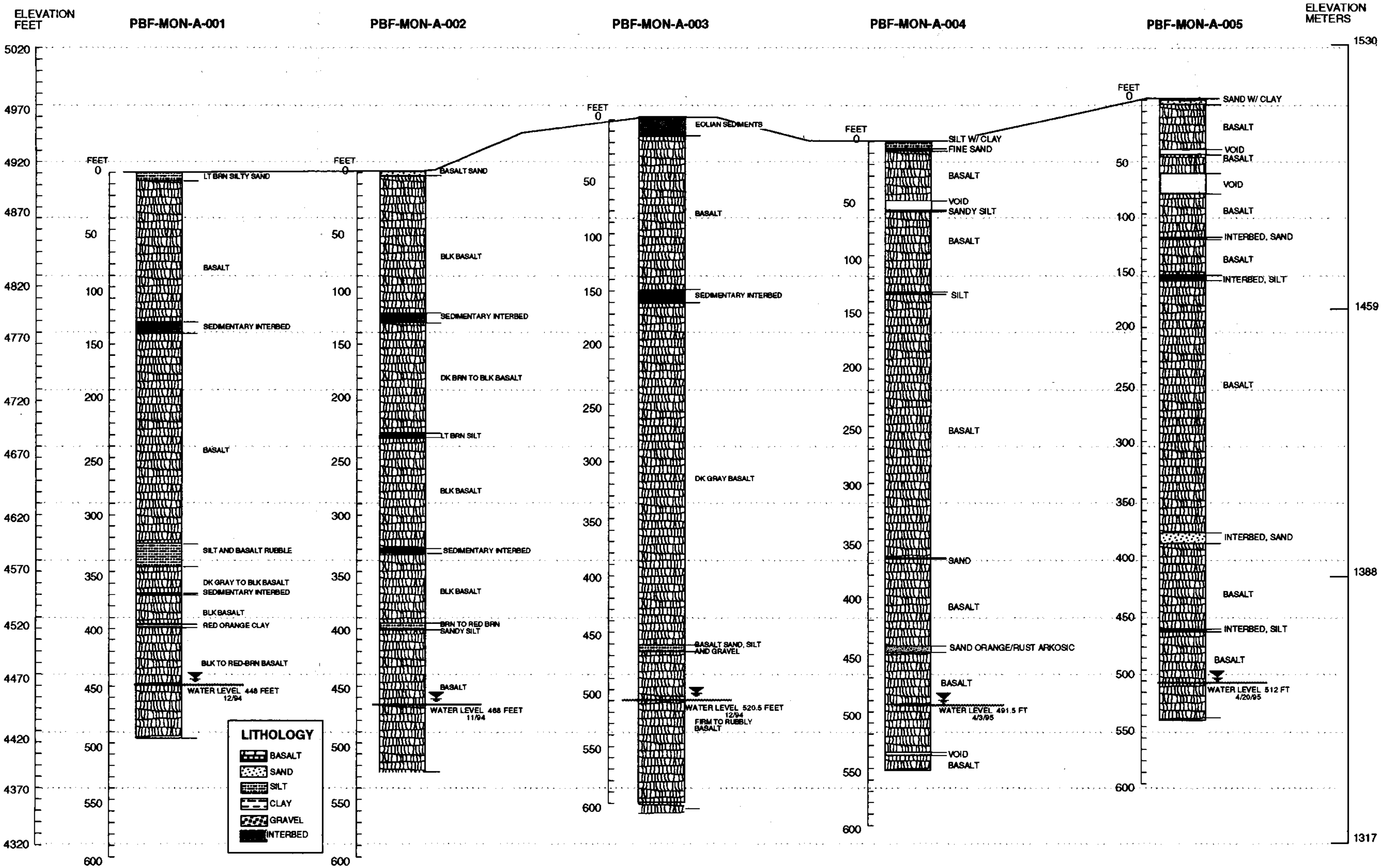


Figure 2-8. Lithology in Power Burst Facility area aquifer monitoring wells.

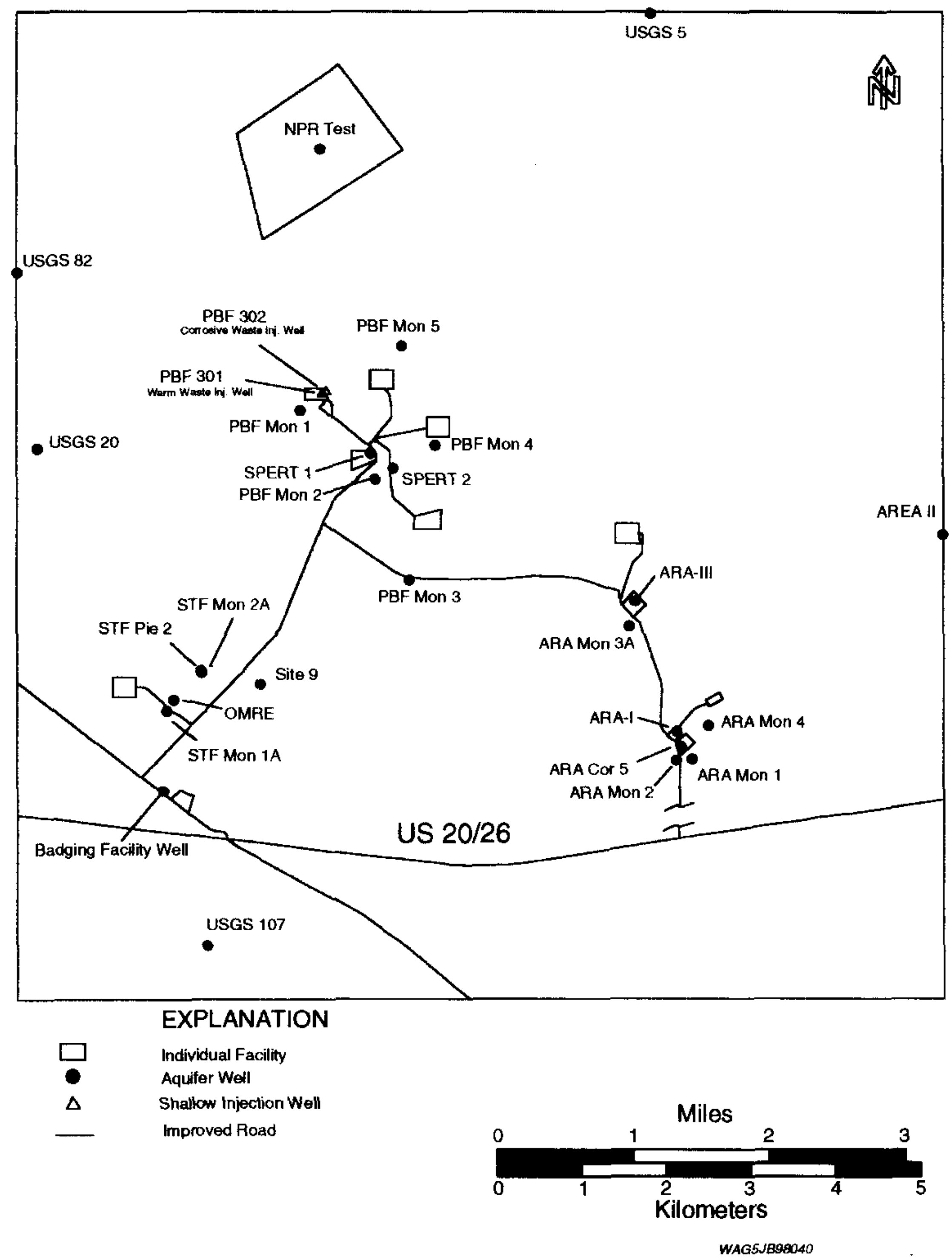


Figure 2-9. Well locations in the WAG 5 area.

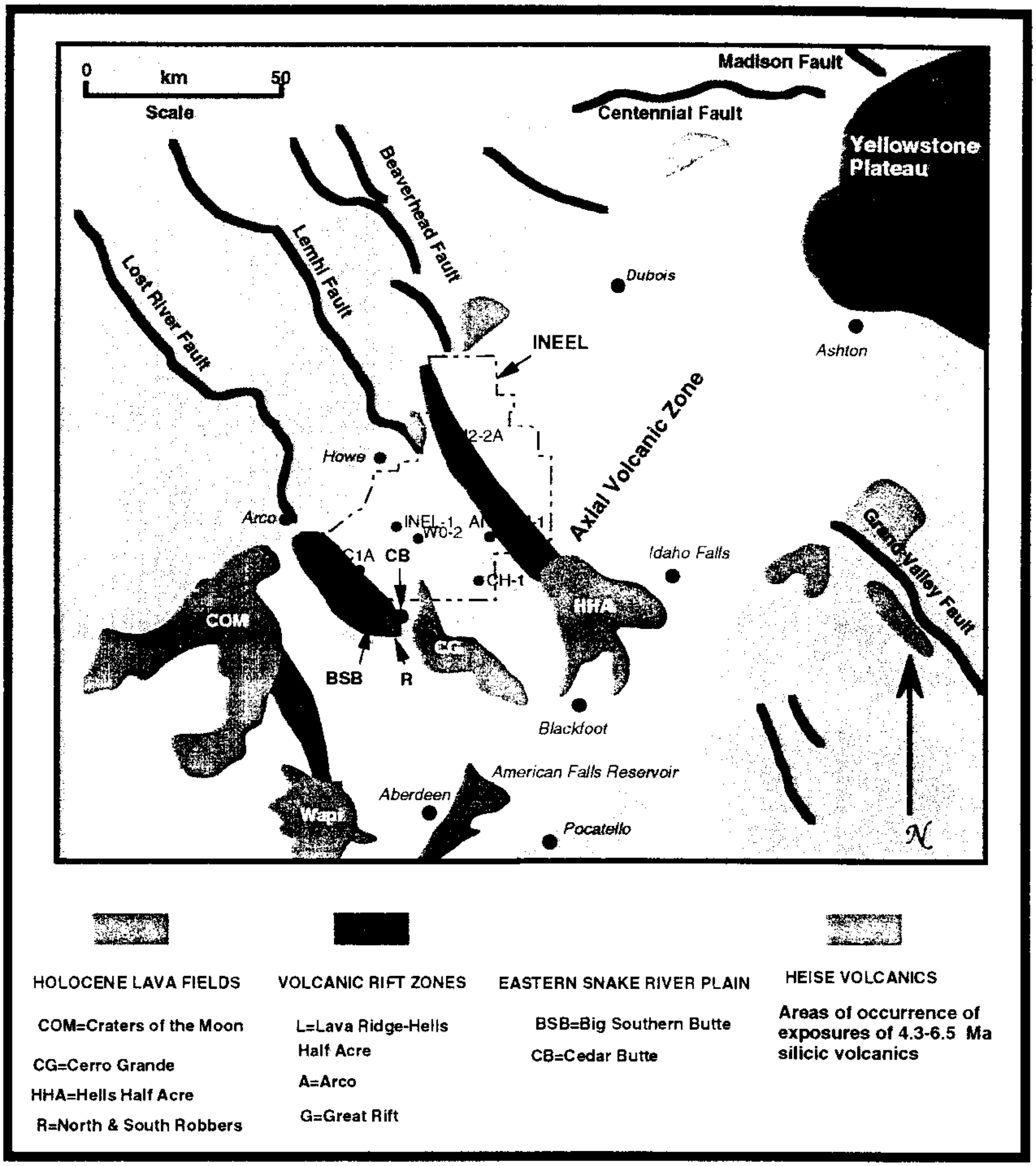


Figure 2-10. General geologic, volcanologic, and tectonic features of the Eastern Snake River Plain.

According to Hackett, Leussen, and Ferdock (1987), past patterns of volcanism suggest that future volcanism at the INEEL within the next 1,000 to 10,000 years is very improbable. The two most likely sources of future basalt flows are the Arco Big Southern Butte and the Lava Ridge Hell's Half Acre rift zones. Lava from these rifts would tend to move south away from the INEEL because of the gentle negative gradient from north to south on the surface of the ESRP (Hackett, Pelton, and Brockway 1986).

2.2.3.4 Surficial Soils. The INEEL soils are derived from Cenozoic felsic volcanic and Paleozoic sedimentary rocks from nearby mountains. The soils in the northern portion of the INEEL are generally composed of fine-grained lacustrine and eolian deposits of unconsolidated clay, silt, and sand. Typically, the soils in the southern INEEL are shallow, consisting of fine-grained eolian soil deposits with some fluvial gravels and gravelly sands (EG&G 1988). Across the Site, measured surficial soil thicknesses range from zero at the basalt outcroppings east of the Idaho Nuclear Technology and Engineering Center (INTEC) to 95 m (313 ft) near the Big Lost River Sinks southwest of TAN (Anderson, Liszewski, and Ackerman 1996). Surface soils in the vicinity of WAG 5 are generally thin, with the greatest thicknesses located either in isolated, discontinuous pockets in low-lying areas or on the leeward side of ridges. Data from well logs indicate average surface sediment thicknesses of 0.4 m (1.5 ft) at the ARA and 3 m (10 ft) at PBF (Holdren et al. 1997).

2.2.4 Hydrology

2.2.4.1 Surface Hydrology. Surface hydrology at the INEEL includes water from three streams that flow intermittently onto the INEEL and from local runoff caused by precipitation and snow melt. Most of the INEEL is located in the Pioneer Basin into which three streams drain: the Big Lost River, the Little Lost River, and Birch Creek. These streams receive water from mountain watersheds located to the north and northwest of the INEEL. Stream flows often are depleted before reaching the INEEL by irrigation diversions and infiltration losses along stream channels. The Pioneer Basin has no outlet; therefore, when water flows onto the INEEL, it typically either evaporates or infiltrates into the ground (Irving 1993).

The Big Lost River is the major surface water feature on the INEEL. Its waters are impounded and regulated by Mackay Dam, which is located approximately 6 km (4 mi) north of Mackay, Idaho. Upon leaving the dam, waters of the Big Lost River flow southeastward past Arco and onto the ESRP. Water from the Big Lost River that actually reaches the INEEL is either diverted at the INEEL diversion dam to spreading areas southwest of the RWMC or flows northward across the INEEL in a shallow channel to its terminus at the Lost River Sinks, at which point the flow is lost to evaporation and infiltration (Irving 1993). Because of above-average mountain snow pack in 1995, water in the Big Lost River was sufficient during the summer of 1995 to flow to the spreading areas and sinks and to the playas south of TAN. Flow during this timeframe ranged from 13.3 m^3/second (469 ft^3/second) near the RWMC in mid-July to 0.8 m^3/second (29 ft^3/second) in early August (Becker et al. 1996).

The Little Lost River drains from the slopes of the Lemhi and Lost River ranges. Flow in the Little Lost River is diverted for irrigation north of Howe, Idaho, and does not normally reach the INEEL. Springs below Gilmore Summit in the Beaverhead Mountains and drainage from the surrounding basin are the source for Birch Creek. Flowing in a southeasterly direction between the Lemhi and Bitterroot ranges, the water of Birch Creek is diverted north of the INEEL for irrigation and hydropower during the summer months. During the winter months, water not used for irrigation is returned to an anthropogenic channel on the INEEL 6 km (4 mi) north of TAN, in which the water infiltrates into channel gravels, recharging the aquifer (Irving 1993). Figure 2-11 shows the major surface water features of the INEEL. No significant surface water features are located within WAG 5.

2.2.4.2 *Subsurface Hydrology.* Subsurface hydrology at the INEEL is discussed as three components: the vadose zone, perched water, and the SRPA. The vadose zone, also referred to as the unsaturated zone, extends from the land surface down to the water table. The water content of the geologic materials in the vadose zone commonly is less than saturation, and water is held under negative pressure. Perched water in the subsurface forms as discontinuous saturated lenses suspended in the vadose zone. Unsaturated conditions exist both above and below the perched water lenses. Perched water bodies are formed by vertical, and to a lesser extent, lateral migration of water moving away from a source until an impeding sedimentary layer is encountered. The SRPA, also referred to as the saturated zone, occurs at various depths beneath the ESRP. About 9% of the aquifer lies beneath the INEEL (DOE-ID 1996) at depths ranging from 61 to more than 274 m (200 to 900 ft) (Irving 1993). The SRPA, which consists of basalt and sediments and the groundwater stored in these materials, is one of the largest aquifers in the United States (Irving 1993) and was classified as a sole-source aquifer by the EPA in 1991 (DOE-ID 1996).

The vadose zone is a particularly important component of the INEEL hydraulic system. First, the thick vadose zone affords protection to groundwater by acting as a filter and preventing many contaminants from reaching the SRPA. Second, the vadose zone acts as a buffer by providing storage for large volumes of liquid or dissolved contaminants that have spilled on the ground or migrated from disposal pits and ponds, or have otherwise been released to the environment. Third, the vadose zone is important because transport of contaminants through the thick, mostly unsaturated materials can be slow if low-infiltration conditions prevail.

An extensive vadose zone exists at the INEEL ranging in thickness from 61 m (200 ft) in the north to more than 274 m (900 ft) in the south and consists of surficial sediments, relatively thin horizontal basalt flows, and occasional interbedded sediments (Irving 1993). The depth to the water table is somewhat variable at WAG 5. The vadose zone is approximately 189 m (620 ft) thick beneath the ARA. At PBF, the average vadose zone thickness is approximately 139 m (455 ft) but varies as much as 7 m (23 ft) within the immediate vicinity of PBF (DOE-ID 1997) (see Figure 2-7). Approximately 90% of the vadose zone comprises thick sequences of interfingering basalt flows. These sequences are characterized by large void spaces resulting from fissures, rubble zones, lava tubes, undulatory basalt-flow surfaces, and fractures. Sedimentary interbeds found in the vadose zone consist of sands, silts, and clays and are generally thin and discontinuous. Sediments may be compacted because of original deposition and subsequent overburden pressures. Under unsaturated conditions with limited water, the flow will avoid large openings, moving preferentially through small openings in sediment or basalt. The cumulative thickness of the vadose zone sedimentary materials ranges from 5.4 to 17.6 m (18 to 58 ft) beneath the ARA and 3 to 13 m (10 to 42 ft) under PBF (Holdren et al. 1997).

Perched water at the INEEL forms when a layer of either dense basalt or fine sedimentary materials occurs with a hydraulic conductivity that is sufficiently low so that vertical movement of the water is restricted. Once perched water develops, lateral movement of the water can occur, perhaps by up to hundreds of meters. When perched water accumulates, the hydraulic pressure increases and water filters through the less permeable perching layer and continues its generally vertical descent. If another restrictive zone is encountered, perching again may occur. The process can continue, resulting in the formation of several perched water bodies between the land surface and the water table. The volume of water contained in perched bodies fluctuates with the amount of combined recharge available from precipitation, surface water, and anthropogenic sources. Perching behavior tends to slow the downward migration of percolating fluids that may be flowing rapidly, under transient near-saturated conditions, through the vadose zone. Historically, perched water has not been detected at WAG 5, but has been found beneath the RWMC, ANL-W, the Test Reactor Area (TRA), and the INTEC. The absence of perched water beneath WAG 5 may be related to the sedimentary interbeds that appear to be discontinuous and limited in areal extent. More likely, however, perched water has not developed

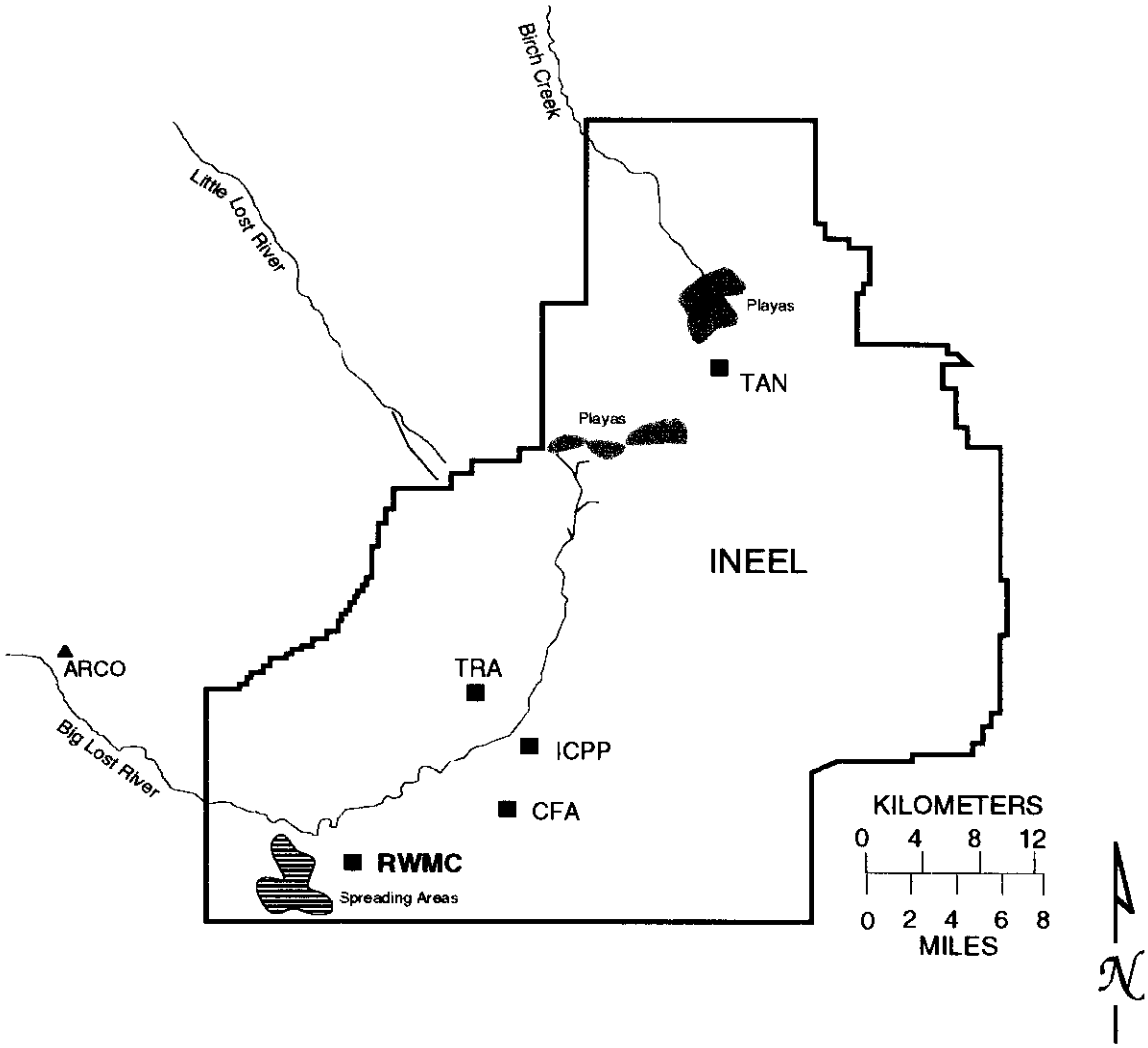


Figure 2-11. Surface water features of the INEEL.

beneath WAG 5 because volumes of infiltrating water are not sufficient. The formation of perched water at the INEEL typically requires an anthropogenic source of infiltration, such as an evaporation pond, to exceed the infiltration caused by normal precipitation found at the INEEL and recharge perched water zones.

The SRPA is defined as the saturated portion of a series of basalt flows and interlayered pyroclastic and sedimentary materials that underlie the ESRP. The SRPA extends from Bliss and the Hagerman Valley on the west to Ashton and Big Bend Ridge on the northeast. The lateral boundaries of the SRPA are formed at its points of contacts with less permeable rocks at the margins of the plain. The SRPA arcs approximately 354 km (220 mi.) through the eastern Idaho subsurface and varies in width from approximately 80 to 113 km (50 to 70 mi.). The total area of the SRPA is estimated at 24,862 km^2 (9,600 $mi.^2$). The depth to groundwater at the INEEL ranges from approximately 61 m (200 ft) below land surface in the north to more than 274 m (900 ft) in the south (Irving 1993). The aquifer contains numerous, relatively thin basalt flows extending to depths of 1,067 m (3,500 ft) below land surface. In addition, the SRPA is characterized by sedimentary interbeds that are typically discontinuous. The SRPA has been estimated to hold 2.5E+12 m^3 (8.8E+13 ft^3) of water, which is approximately equivalent to the amount of water contained in Lake Erie, or enough water to cover the entire State of Idaho to a depth of 1.2 m (4 ft) (Hackett, Pelton, and Brockway 1986). Water is pumped from the aquifer primarily for human consumption and irrigation (Irving 1993). Compared to such demands, INEEL use of the aquifer is minor.

Aquifer permeability is controlled by the distribution of highly fractured basalt flow tops, interflow zones, lava tubes, fractures, vesicles, and intergranular pore spaces. The areal extent and degree of contact between highly conductive zones complicate the direction of groundwater movement locally throughout the aquifer. The permeability of the aquifer varies considerably over short distances, but generally a series of basalt flows include several zones of high permeability.

The SRPA is recharged primarily by infiltration from rain and snowfall that occurs within the drainage basins surrounding the ESRP and from deep percolation of irrigation water. Annual recharge rates depend on precipitation, especially snowfall. Regional groundwater flows to the south-southwest; however, locally the flow direction can be affected by recharge from rivers, surface water spreading areas, and heterogeneities in the aquifer. Estimates of flow velocities within the SRPA range from 1.5 to 6.1 m/day (5 to 20 ft/day) (Irving 1993). Flow in the aquifer primarily is through fractures, interflow zones in the basalt, and in the highly permeable rubble zones located at the tops of basalt flows. The SRPA is considered heterogenous and anisotropic (having properties that differ depending on the direction of measurement) because of the permeability variations within the aquifer that are caused by basalt irregularities, fractures, void spaces, rubble zones, and sedimentary interbeds. The heterogeneity is responsible for the variability in transmissivity values (measures of the ability of the aquifer to transmit water) through the SRPA. Transmissivities measured in wells on the INEEL range from 1.0E-01 to 1.1E+06 m^2/day (1.1E+00 to 1.2E+07 ft^2/day) (Wylie et al. 1995). Concerns about groundwater contamination from INEEL operations have prompted an extensive monitoring system over all of the INEEL (Irving 1993). Over the vast majority of the INEEL, maximum contaminant levels (MCLs) are not exceeded.

2.2.4.3 WAG 5 Hydraulic Gradient. The hydraulic gradient at WAG 5 was evaluated in 1996 and 1997 (Dustin 1996; Neher January 1997; Neher March 1997) to support the WAG 5 Work Plan (DOE-ID 1997). The evaluation included (1) collecting three quarterly groundwater elevation measurements from 20 wells in and around WAG 5 beginning in August 1996, (2) reviewing borehole lithology, deviation, and well construction for 37 wells in and around WAG 5 to develop water table contour maps, (3) evaluating barometric data during each ground water monitoring event to determine potential barometric influences on the resulting water table contour maps, and (4) continuous monitoring of water levels in Wells PBF-MON-A-3 and PBF-MON-A-4 for a period of 16 days to determine the effects, if any, from PBF production well pumping on the WAG 5 area water table. The results of the evaluation were used to develop the WAG 5 water table contour map presented in Figure 2-12. Well construction, barometric effects on water level measurements, and the effect of production well pumping were found to have no influence on the resulting water table contour interpretation. The contour map and inferred groundwater flow paths presented in Figure 2-12 are considered an accurate representation of the aquifer flow system beneath WAG 5 and are most likely the result of heterogeneity in the aquifer.

The hydraulic gradient evaluation shows that measured water table elevations in the WAG 5 area range from 1,362 m (4468 ft) in Well USGS 5 to 1,352 m (4,435 ft) in Well USGS 107 (see Figure 2-12). The depth to the water table ranges from 189 m (620 ft) in Well AREA-II to 139 m (455 ft) in Well USGS 82. Thus, the water table gradient varies widely beneath WAG 5. The general gradient is about 0.8 m/km (4 ft/mi) to the south and southwest. However, a fairly steep southeast gradient occurs beneath the PBF area with a gradient of approximately 4 m/km (23 ft/mi). A review of borehole deviation logs and barometric data collected during each quarterly measurement event indicates that neither of these two factors has a significant effect on the resulting water table contour map. In addition, an evaluation of the effects of pumping the PBF production wells, SPERT 1 and SPERT 2, indicates that local pumping is not causing the gradient beneath PBF. Based on the available data, it appears that the steep water table gradient beneath PBF is most likely the result of aquifer heterogeneity. The existing monitoring network is adequate, as shown by the SL-1 sensitivity analysis (see Magnuson and Sondrup 1998 in Appendix J) and because WAG 5 operations primarily generated surface contamination, not groundwater contamination.

Information obtained during quarterly water level measurements also indicates a potentially confined or semi-confined deeper portion of the aquifer in the WAG 5 area. Monitoring of the Site 9 well, which has a well screen at an elevation of 1,197 m (3,926 ft) or approximately 160 m (525 ft) below the measured water level, has revealed a hydraulic head approximately 3.7 m (12 ft) higher than expected, given the water table elevation in surrounding wells. The higher hydraulic head in Site 9 is most likely the result of confined or semi-confined conditions at depth. This inference is supported by the presence of several thick clay layers observed at elevations between 1,310 m (4,300 ft) and 1,220 m (4,000 ft) in the well logs from the Site 9, SPERT 2, and Organic-Moderated Reactor Experiment (OMRE) wells.

2.3 Cultural Resources

In response to federal environmental legislation, investigations of INEEL cultural resources were initiated in the late 1960s. Several categories of cultural resources have been identified within the INEEL facility boundaries, including prehistoric and historic archaeological sites, Native American traditional cultural sites, paleontological sites, and contemporary historical sites. The INEEL Management Plan for Cultural Resources (Miller 1995) contains a comprehensive history of cultural resource management activities at the INEEL; a summary of the results of the compliance-driven research conducted for the cultural history, and a synopsis of the legal mandates for cultural resource management in the United States.

2.3.1 INEEL Cultural Resources

Over the past two decades, detailed inventories of cultural resources at some parts of the INEEL have been assembled. Initial surveys have been focused on areas within and around major operating facilities at the Site. Proposed future construction areas also have been examined. As of January 1, 1998, approximately 6.6% (37,681 acres) of the 890-mi^2 INEEL has been systematically surveyed for

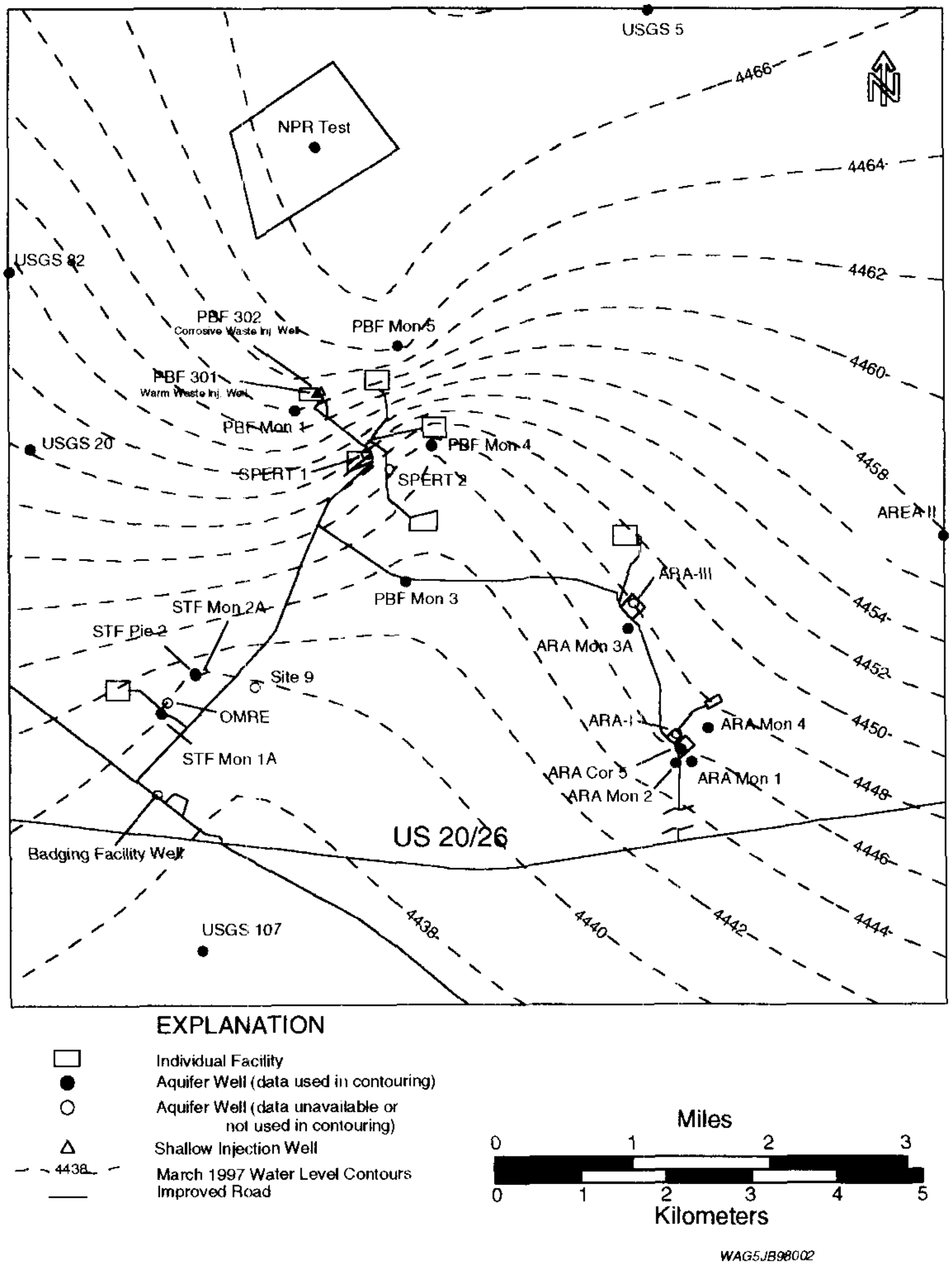


Figure 2-12. Well locations and groundwater gradient in the WAG 5 area.

archaeological resources and 1,839 archaeological localities have been identified. The inventory includes prehistoric resources representing a span of approximately 12,000 years as well as historic resources representing the last 150 years. Consultation with Shoshone-Bannock tribal representatives has revealed that all archaeological resources, along with other natural features of the INEEL region, are of traditional cultural importance. Cultural resources on the INEEL also include a number of more recent buildings, structures, and objects that have made significant contributions to the broad patterns of American history through their association with World War II, the Cold War, and important advances in nuclear science and technology.

While more than half of the archaeological resources currently identified on the INEEL may be eligible for the National Register of Historic Places, none has been formally nominated. One INEEL facility, the Experimental Breeder Reactor I, is recognized as a National Historic Landmark.

2.3.1.1 Prehistoric Archaeological Sites. Archaeological sites are numerous on the INEEL (i.e., the presence of about 40,000 sites has been estimated), some of which represent occupation by Native American hunter-gatherers from 12,000 to 150 years ago. The seminomadic lifestyle of these early occupants was ideal to take advantage of the multitude of resources seasonally available in the INEEL region and is reflected in a variety of archaeological resource types such as long-term campsites situated along the Big Lost River, smaller short-term hunting campsites, game and plant processing areas, stone tool manufacturing areas, and various rock alignments including cairns, hunting blinds, and game drives.

2.3.1.2 Historic Archaeological Sites. Evidence of fur trapping and trading, Oregon Trail immigration, homesteading, ranching, and agricultural pursuits from the late 1800s to the 1940s is preserved in archaeological sites, as well as a few dilapidated structures, crumbling foundations, and many miles of trails and canals. Of the archaeological resources on the INEEL, 6% have been identified as historical.

2.3.1.3 Native American Traditional Cultural Sites. Local Native American people, particularly the Shoshone-Bannock tribal members of Fort Hall, Idaho, view all of the prehistoric sites on the INEEL as ancestral and of traditional cultural significance. A variety of natural features also are important to Native Americans. Though rare on the INEEL, Native American burial sites are of special concern. Efforts to assemble a comprehensive inventory of these traditional cultural places have just begun. In the absence of a comprehensive listing, consultation directly with tribal representatives is recommended to ensure that no significant resources are inadvertently harmed by INEEL activities.

2.3.1.4 Paleontological Sites. Over the past three decades, 25 paleontological localities, many with important information on past climatic conditions and vertebrate faunas, have been identified in subsurface excavations at the INEEL. Most have been recovered from floodplain deposits along the Big Lost River.

2.3.1.5 Contemporary Historic Sites. Inventories of buildings, structures, and significant objects within the contemporary environment at the INEEL are in the early stages. A 1997 survey of 516 buildings administered by DOE-ID resulted in the identification of 217 that are potentially eligible for nomination to the National Register of Historic Places either individually or as contributing elements in a historic district (Arrowrock 1997). In addition, the remaining buildings, as well as many as yet unsurveyed structures and objects, contribute to the overall INEEL historic landscape. Detailed historical documentation is under development or has been completed for several of the significant facilities included in this inventory.

2.3.2 WAG 5 Cultural Resources

Many cultural resource investigations have been completed in the WAG 5 area (Miller 1995). Activities have included archaeological surveys (Reed et al. 1987) and test excavations (Ringe 1988), excavations of sensitive Native American burial sites (Miller 1994, 1997), historic building inventories (Arrowrock 1997), and the development of detailed documentation (DOE-ID 1993).

2.3.2.1 Ahaeological Sites and Traditional Cultural Sites. Since 1984, six major archaeological survey projects encompassing nearly 1,200 acres have been completed in the PBF area. As a result, 86 sensitive resources have been identified within or immediately adjacent to the fenced perimeter of the facility. Resources include hunting campsites and game processing areas, stone tool processing areas, hunting blinds made of locally available basalt cobbles, and Native American burial sites. Shoshone-Bannock tribal members have indicated that the sandy ridges and basins so common to WAG 5 may contain additional areas of traditional cultural importance. Limited archaeological test excavations completed in 1988 and intensive investigations of Native American human remains discovered 1994 and 1996 provide further evidence of the sensitivity of the area and indicate a high potential for stratified subsurface cultural deposits, even in areas where no surface indications are apparent. Ground-disturbing activities proposed for the PBF area, in which the Native American human remains were discovered, should be carefully planned in consultation with tribal representatives to avoid or mitigate adverse impact to the known archaeological sites in the sensitive region.

Relatively recent archaeological surveys of the ARA facilities have revealed a number of significant archaeological resources. Examination of 255 acres within and around the fenced facility perimeters has resulted in the preliminary documentation of 14 sensitive archaeological resources. Generally, these resources are very similar to those identified within the PBF area, though no Native American burial sites are currently identified at ARA. Places of traditional cultural importance may be identified through consultation with Shoshone-Bannock tribal representatives. As in the PBF area, any proposed ground disturbance should be preceded by careful consideration of known archaeological resources and consultation with the Shoshone-Bannock tribal representatives.

2.3.2.2 Contemporary Historic Sites. The experiments conducted within the PBF complex in the 1960s and early 1970s provided the nuclear industry with information needed for the design and safe operation of boiling water, pressurized water, heavy water, and open pool reactors. In a preliminary survey of buildings administered by DOE-ID (Arrowrock 1997), 16 of the 27 buildings associated with the PBF experiments are potentially eligible for nomination to the National Register of Historic Places. Detailed historical documentation must be completed in the event of proposed demolition or major structural modification to any of these 16 buildings. Such documentation must be formalized through a memorandum of agreement between DOE-ID and the Idaho State Historic Preservation Office.

Experiments conducted in the 1960s at the ARA facilities were designed to test reactor concepts and applications for the U.S. Army. Detailed historical documentation of the buildings and structures associated with this work was initiated in 1993 in conjunction with D&D activities (DOE-ID 1993). When the historical documentation package is completed in December of 1998, it will be submitted to the National Park Service and permanently archived at the U.S. Library of Congress.

2.4 Flora and Fauna

Six broad vegetation categories representing nearly 20 distinct habitats have been identified on the INEEL: juniper-woodland, native grassland, shrub-steppe off lava, shrub-steppe on lava, modified, and wetlands. Nearly 90% of the Site is covered by shrub-steppe vegetation, which is dominated by big sagebrush, saltbush, rabbitbrush, and native grasses. In addition to the predominant sagebrush-steppe communities, small riparian and wetland regions exist along the Big Lost River and Birch Creek and have been identified as biological resource areas within the Site (DOE-ID 1996).

The INEEL serves as a wildlife refuge because a large percentage of the Site is undeveloped and human access is restricted. Grazing and hunting is prohibited in the central part of the Site. Mostly undeveloped, this tract may be the largest relatively undisturbed sagebrush steppe in the Intermountain West outside of the national parklands (DOE-ID 1996). More than 270 vertebrate species including 43 mammalian, 210 avian, 11 reptilian, nine fish, and two amphibious species have been observed on the Site. During some years, hundreds of birds of prey and thousands of pronghorn antelope and sage grouse winter on the INEEL. Mule deer and elk also reside at the Site. Observed predators include bobcats, mountain lions, badgers, and coyotes. Bald eagles, classified as a threatened species, are commonly observed on or near the Site each winter. Peregrine falcons, which are classified as endangered, also have been observed. In addition, other species that are candidates for listing as threatened or endangered by the U.S. Fish and Wildlife Service may either inhabit or migrate through the area. Candidate species that may frequent the area include ferruginous hawks, pygmy rabbits, Townsend's big-eared bats, burrowing owls, and loggerhead shrikes. No identified ecologically sensitive areas (i.e., areas of critical habitat) are located within WAG 5 (Holdren et al. 1997).

2.5 Demography and Land Use

2.5.1 Demography

The populations potentially affected by INEEL activities include INEEL employees, ranchers who graze livestock in areas on or near the INEEL, hunters on or near the Site, residential populations in neighboring communities, and highway travelers.

2.5.1.1 On-Site Populations. Nine separate facilities at the INEEL include a total of approximately 450 buildings and more than 2,000 other support facilities. In January 1996, the INEEL employed 8,616 contractor and government personnel. Approximately 60% of the total work force is employed at the INEEL Site and 40% is located in Idaho Falls, Idaho (DOE-ID 1996).

According to DOE-ID (1996), as of 1996, approximately 112 employees were working at PBF. As mentioned in Section 2.1, ARA is not an active facility. Decommissioning and dismantlement crews have been working at ARA-I, -II, and –III, and personnel occasionally visit ARA-IV. However, a full-time staff is not maintained at ARA. Employee totals at other INEEL locations include approximately 190 at the RWMC; 883 at the CFA; 360 at TAN; 470 at TRA; 1,300 at NRF; 1,162 at the INTEC; 750 at ANL-W; and 10 within the remaining Site-wide areas, which include ARA. In addition, approximately 3,400 INEEL employees occupy numerous offices, research laboratories, and support facilities in Idaho Falls (DOE-ID 1996).

2.5.1.2 Off-Site Populations. The INEEL Site is bordered by five counties: Bingham, Bonneville, Butte, Clark, and Jefferson. Major communities include Blackfoot and Shelley in Bingham County, Idaho Falls and Ammon in Bonneville County, Arco in Butte County, and Rigby in Jefferson County. Population estimates for the counties surrounding the INEEL and the largest population centers in these counties are shown in Table 2-1 (Becker et al. 1996). The nearest community to the INEEL is Atomic City, located south of the Site border on U.S. Highway 26. Other population centers near the INEEL include Arco, 11 km (7 mi) west of the Site; Howe, west of the Site on U.S. Highway 22/33; and Mud Lake and Terreton on the northeast border of the Site.

Table 2-1. Population estimates for counties surrounding the INEEL and selected communities (1990).

Location	Population Estimate
Bingham County	39,613
Blackfoot	9,300
Shelley	3,400
Clark County	798
Bonneville County	77,395
Ammon	4,800
Idaho Falls	42,200
Butte County	2,940
Jefferson County	17,486
Rigby	2,600

2.5.2 Land Use

2.5.2.1 Current Land Use. The BLM classified the acreage within the INEEL as industrial and mixed use (DOE-ID 1995). The primary use of INEEL land is to support facility and program operations dedicated to spent nuclear fuel management, hazardous and mixed waste management and minimization, cultural resources preservation, and environmental engineering, protection, and remediation. Large tracts of land are reserved as buffer and safety zones around the boundary of the INEEL. Portions within the central area are reserved for INEEL operations. The remaining land within the core of the Site, which is largely undeveloped, is used for environmental research, ecological preservation, and sociocultural preservation.

The buffer consists of 1,295 km^2 (500 mi^2) of grazing land (DOE-ID 1995) administered by the BLM. Grazing areas at the INEEL support cattle and sheep, especially during dry conditions. Depredation hunts of game animals managed by the Idaho Department of Fish and Game are permitted on-Site within the buffer zone during selected years (DOE-ID 1995). Hunters are allowed access to an area that extends 0.8 km (0.5 mi) inside the INEEL boundary on portions of the northeastern and western borders of the Site (Becker et al. 1996).

State Highways 22, 28, and 33 cross the northeastern portion of the Site, and U.S. Highways 20 and 26 cross the southern portion (Figure 2-1). One hundred forty-five km (90 mi) of paved highways used by the general public pass through the INEEL (DOE-ID 1995), and 23 km (14 mi) of Union Pacific Railroad tracks traverse the southern portion of the Site. A government-owned railroad passes from the Union Pacific Railroad through the CFA to the NRF, and a spur runs from the Union Pacific Railroad to the RWMC.

In the counties surrounding the INEEL, approximately 45% of the land is used for agriculture, 45% is open land, and 10% is urban, (DOE-ID 1995). Livestock uses include the production of sheep, cattle, hogs, poultry, and dairy cattle (Bowman et al. 1984). The major crops produced on land surrounding the INEEL include wheat, alfalfa, barley, potatoes, oats, and corn. Sugarbeets are grown within about 40 mi of the INEEL in the vicinity of Rockford, Idaho, southeast of the INEEL in central Bingham County (Idaho 1996). Most of the land surrounding the INEEL is owned by private individuals or the U.S. government. The BLM administers the government land on the INEEL (DOE-ID 1996).

2.5.2.2 Future Land Use. Future land use is addressed in a document on INEEL future land-use scenarios (DOE-ID 1995) and in the Comprehensive Facility and Land Use Plan (DOE-ID 1996). Because future land-use scenarios are uncertain, assumptions were made in the INEEL future land-use document for defining factors such as development pressure, advances in research and technology, and ownership patterns. The following assumptions were applied to develop forecasts for land use within the INEEL:

- The INEEL will remain under government ownership and control for at least the next 100 years. Though the INEEL land-use document (DOE-ID 1995) indicates that the boundaries of the INEEL may shrink, the boundary is static in the WAG 5 baseline risk assessment.

- The life expectancy of current and new facilities is expected to range between 30 and 50 years. The D&D process will commence following closure of each facility if new missions for the facility are not determined.

- No residential development (e.g., housing) will occur within the INEEL boundaries within the institutional control period.

- No new major, private developments (residential or nonresidential) are expected in areas adjacent to the INEEL.

Generally, future land use within the INEEL will remain essentially the same as the current use: a research facility within the INEEL boundaries and agriculture and open land surrounding the INEEL. Other potential but less likely land uses within the INEEL include agricultural and the return of the areas on-Site to their natural, undeveloped state. The DOE land use plan (DOE-ID 1996) projects that ARA will be encompassed by a future buffer to public roads (i.e., State Highway 20) and will not be reused for future INEEL operations. Conversely, the forecast for the PBF area includes modification and reuse for industrial operations over the next 100 years (DOE-ID 1996).

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